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LIGHT RAILWAYS

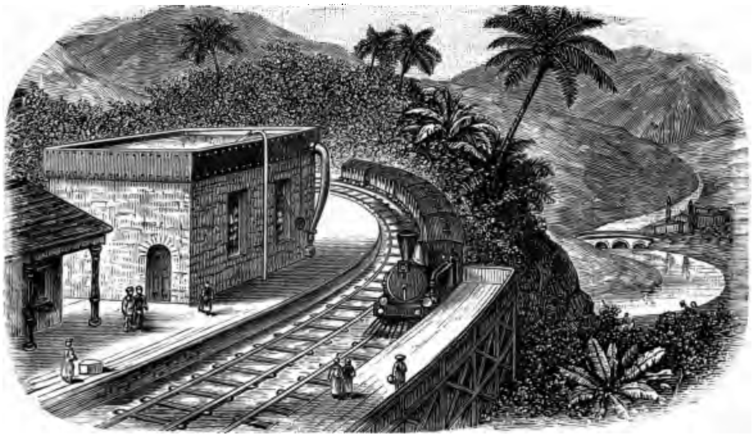
AS A

PRACTICAL MEANS OF EXPLORATION.

BY

E. R. SALWEY

ASSOC. MEM. INST. C.E.



NARROW-GAUGE RAILWAY.

FORTY-EIGHT ILLUSTRATIONS

E. & F. N. SPON, 125 STRAND, LONDON
NEW YORK: 12 CORTLANDT STREET
1890

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TO

HENRY CHARLES BARKLEY,

A BROTHER ENGINEER,

WHO, IN BULGARIA AND BRAZIL,

BY HIS CHEERY NATURE AND KINDLY DISPOSITION,

MADE A ROUGH LIFE IN THOSE FAR-OFF COUNTRIES

A PLEASURABLE EXPERIENCE,

This little book is gratefully dedicated by

THE AUTHOR.

PREFACE.

I HAD intended the subject of Light Railways as a means for exploration of foreign countries to be in the form of a paper for the Institute of Civil Engineers, but in putting together the notes I had by me of such slight experience as I had in their construction in Brazil, I found, although I might condense the subject, it would hardly fall within the limits of such a paper. At the present time I feel also that "exploration" is a matter of almost universal interest, and that there is nothing I have written on the subject of a purely technical character.

It is for these reasons that I have ventured to offer my ideas to the general public. I claim, of course, no originality in the descriptions given of narrow-gauge railways, but seek only to bring prominently forward their suitability as an inexpensive and economical means by which countries already explored may be rapidly civilised, their known resources developed, and become the best means by which explorations may be undertaken. I am also desirous that members of my profession should take an active part in exploration expeditions of the future, feeling confident that this alone is wanted to render practical that valuable information which we derive year by year from the reports of those intrepid travellers who have devoted their lives for the good of mankind, the suppression of the slave-trade, and the advance of civilisation.

I have, I fear, been able to do but scant justice to a subject of so much importance, but the figures given of the cost of construction may be deemed of some value as not being the estimated, but the absolute cost within my own experience in Brazil, and the amounts stated are the actual amounts paid to the contractors by my own measurements and on my own certificates. For the illustrations given of narrow-gauge engines, rolling stock, &c., I am indebted to Messrs. Dick, Kerr & Co., Limited, of 101 Leadenhall Street, E.C., very large manufacturers of this description of railway plant at Kilmarnock, N.B., and the cost of equipment of the railways is based on the prices of this firm.

I will add only, in conclusion, that should anything I have written lead to the consolidation of partially explored and unexplored countries under British influence, and spread Christianity and civilisation into the remote corners of the earth, my object will be more than gained.

E. R. SALWEY.

BRISTOL, *October* 1890.

LIGHT RAILWAYS.

CHAPTER I.

INTRODUCTION.

A GREAT portion of my professional career having been passed in the execution of public works where such railways as I shall describe form a prominent feature, and having been employed myself in their laying out and construction in countries to some extent remote from civilisation, and where the engineer is much thrown on his own and such native resources as he is able to obtain to carry out the work entrusted to his care, I have attempted to give my experience in this little book. My object, then, is to point out the advantage of constructing portable, light, and inexpensive narrow-gauge railways similar to such as I have laid out and constructed in some of the more unexplored parts of Brazil, not necessarily at first for the development of any particular commercial industry, but merely as a means, and, in my opinion, the best and most inexpensive means, of preliminary exploration.

England has at all times stood first amongst the nations of the world in promoting civilisation and in developing the enormous resources of foreign countries for the benefit of those lands to which her explorers have penetrated, as well as for the benefit of the whole human race. To quote those words so aptly embodied in the Charter of the Institute of

Civil Engineers, she has "directed the great sources of power in Nature for the use and convenience of man" in many other countries besides her own. In this nineteenth century we may say in her own country she has indeed reaped a full harvest, but there are still many dark regions on the earth full of natural wealth waiting only to yield it up when those "sources of power in Nature" are properly directed, and as long as this is the case there must always be ample scope for English explorers and English engineers.

The object of this small volume will be to endeavour to point out the advantages of travellers and engineers working hand in hand together. The enormous sums of money and the valuable lives that have been lost in the noble endeavour to spread Christianity, science, or commerce it would be difficult to recount. The results of these enterprises have been great, but I would venture to urge that in many cases, had those pioneers been able to leave behind them, in the remote regions they have visited at so much cost, a record of a practical and tangible nature, the results would have been still greater, and many lives nobly sacrificed might have been spared. I allude, of course, to the valuable aid that would have been afforded by the assistance of engineers to establish permanently, by means of such light railways as I shall presently describe in detail, those lines of communication which have been discovered.

We have, it is true, the benefit of their researches in the reports furnished to us of the physical features, natural capabilities, and productions of previously unknown countries; and such valuable and reliable information from eye-witnesses induces capitalists to call in the assistance of engineers to open up the country and develop the resources known to exist.

This, however, is a slow process, and my contention is that engineers should lead the van rather than follow in the wake of explorers. To travel through a new country without establishing permanent communications may be compared to ruling a line in water. There is no trace left behind; and in spite of the dangers of the expedition, in spite of the hardships endured and difficulties successfully overcome by the indomitable pluck, energy, and perseverance of the first party of explorers, even if they ever return to us to give an account of their travels, the task of revisiting that land by any exploration party in the future is just as difficult as if the route had not previously been traced.

If we take the exploration of Equatorial Africa, such great names as Speke, Grant, Livingstone, Gordon, Emin Pasha, and Stanley at once occur to us. I need not dwell here upon their exploits, so well known to the whole civilised world, but I would suggest that the results of their efforts have been minimised for want of establishing, by the assistance of engineers, those possible lines of communication they have discovered. In some of these instances we have but the memory of these great names left to us, and I think, humanly speaking, it is not too much to say their lives might have been spared could they have been supplied with the means of establishing stations and communications with that civilisation which step by step they left behind them as their explorations advanced.

Is it too much to say that the life of General Gordon himself might have been spared had the Souakim-Berber Railway been constructed, and that route adopted for the occupation of the Soudan?

How slowly, too, in Equatorial Africa does exploration progress and civilisation follow, and may not this slow rate of progress be attributed to the same cause?

Before the fifteenth century, Europeans had some general knowledge of the North coast of Africa, and the Nile was known then beyond Khartoum.

In 1486 Diaz made his famous voyage on the West coast.

In 1497 Vasco de Gama doubled the Cape, and about the year 1550 the Portuguese had acquired a fair knowledge of the African coast. Since that date some nine hundred explorers have worked their way across the face of this mighty continent, six hundred of whom have perished through disease or murder.

Livingstone began his labours in 1840, and at that time the centre of Africa was practically unknown. He died there in 1873, and he had in those thirty-three years been able to map out lakes, rivers, and mountains. He was the first European to cross Africa from ocean to ocean, and make known the existence of one million square miles of country.

Burton and Speke in 1858 traced a route along the coast to Zanzibar, and discovered the Victoria Nile. Speke and Grant were the first to sail on the Albert Nyanza, the second great lake of the Nile. The south watershed of the Congo was discovered by Cameron, and Stanley in 1874 circumnavigated the Victoria Nyanza and made his celebrated voyage down the Congo. His recent expedition undertaken for the relief of Emin Pasha is fresh in our memory, and his interesting description of the lakes, forests, and mountains which he traversed.

I merely allude to these facts to show that the exploration of South Africa is no new thing. Attempts have been made extending, as we have seen, over a period of four hundred years, and still each new expedition that is organised has the same difficulties and dangers, and the same hairbreadth escapes from disease, murder, and famine to encounter.

By this country alone what must have been expended in this period of time by these expeditions it would be difficult to estimate. The question therefore naturally arises, Are the results commensurate with the cost? and are we not at the present day almost as far from carrying civilisation into the heart of this great continent as we were four hundred years ago? Had engineers had at their disposal but a small part of the money that these expeditions have cost, and expended it in the construction of inexpensive railways, and such bridges, roads, and harbour improvements as were found requisite, the riches of Africa would have long since flowed to our shores, and by this time ample trade would have been created in which all the civilised nations in the world would have participated.

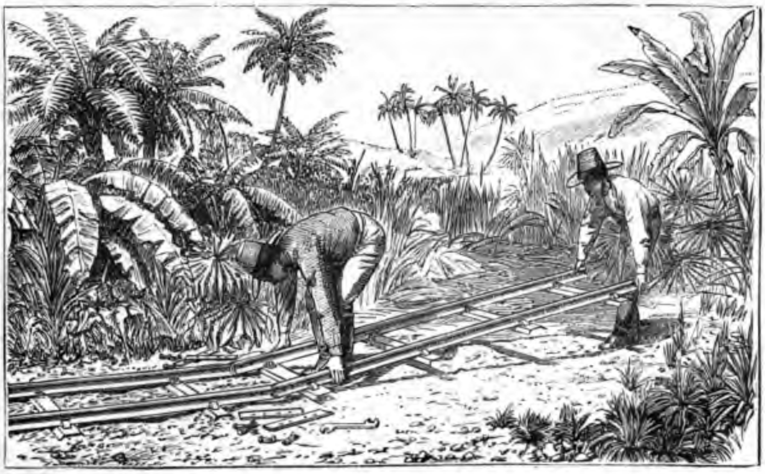
No doubt there are many instances of concessions having been obtained and railways having been constructed in advance of the requirements of trade or commerce, and in such cases there is a serious loss of capital involved, and here again, I think, a great saving could have been effected by laying down, in the first instance, light and inexpensive railways sufficient for the requirements of the traffic known to exist. Such lines could afterwards, at no great additional cost, be altered as more produce had to be carried over them. The formation width would then be increased, bridges and culverts widened, heavier rails laid down, and suitable rolling stock provided. All this would be done gradually, section after section, commencing from the base and the light permanent way; engines, trucks, and carriages as released would be carried to the front and relaid, to push still further into the interior and to develop fresh tracts of country.

As an illustration of the loss occasioned by constructing heavy main trunk lines in countries where insufficient traffic exists to warrant the outlay, I may quote an instance in my own professional experience.

Twenty-five years ago I was engaged as a young engineer on the railway then recently constructed between Rustchuck, on the Danube, and Varna, a port on the Black Sea in Bulgaria (then part of the Turkish empire). The length of this line is 140 miles, and the cost of construction and equipment no less than £3,000,000, or £21,428 per mile. Although the line traversed a rich, fertile, and grain-producing country, there was not sufficient traffic to give an adequate return for such an enormous expenditure. At that time there was a certain amount of passenger traffic from the Danube steamers calling at Rustchuck, whence passengers and mails were conveyed over the line to Varna, and from there by steamers crossing the Black Sea to Constantinople. As soon, however, as the railway through Roumelia from Belgrade to Constantinople (four hundred miles) was opened, this traffic was naturally taken by the more direct and quicker route, and the Varna and Rustchuck Railway became dependent upon the goods traffic (chiefly grain) and such local passenger traffic as there was to support it. But few roads then existed in the country, and, in fact, the carrying capacity of this heavy railway was far in excess of the traffic to be conveyed, and could by no possibility for many years pay any adequate return on so large an outlay.

This I take as an instance where such light railways as I am advocating would at any rate have sufficed for many years to do all the work required, and could have been laid down and equipped for one-twentieth of the cost. The country was a fairly easy one from an engineering point of view—no tunnel from end to end, banks and cuttings not heavy, and only one viaduct of any length.

Another railway on which I was employed in constructing commenced on the other side of the Danube opposite Rustchuck, at a place called Giurgevo, in Wallachia, and was forty miles in length, connecting the Danube with the important city of Bucharest. Here, however, the conditions are different, civilisation being much farther advanced, and on the opening of that railway it became at once evident that the promoters were fully justified in the outlay, and that their expectations as to the results had not been of too sanguine a nature.



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CHAPTER II.

I do not propose in this volume to advocate any particular system of light railways, but shall describe somewhat in detail the railways or trams we constructed in Brazil, showing the actual cost from notes taken at the time. The work upon which we were engaged in that country was not entirely in connection with railways. We had six large sugar factories to build in different parts of the province of Pernambuco. Each of these factories was provided with machinery capable of crushing 350 tons of sugar-cane per day, and the trams were therefore laid down for a certain distance from each factory into the sugar-cane plantations in order to feed the mills with this quantity of cane daily during the crushing season. We had our sites to select, bricks and tiles to be made and burnt, machinery to discharge in a port without a harbour, to convey it up the country to the different factories, as well as to erect it, besides the work of laying out and constructing our tram-lines, and we were but a small party of engineers with a limit of fourteen months for the execution of all this work, in a tropical climate and difficult country. It was, however, successfully accomplished, and to my share more particularly fell the setting out and construction of the tram-lines, with which I now propose to deal.

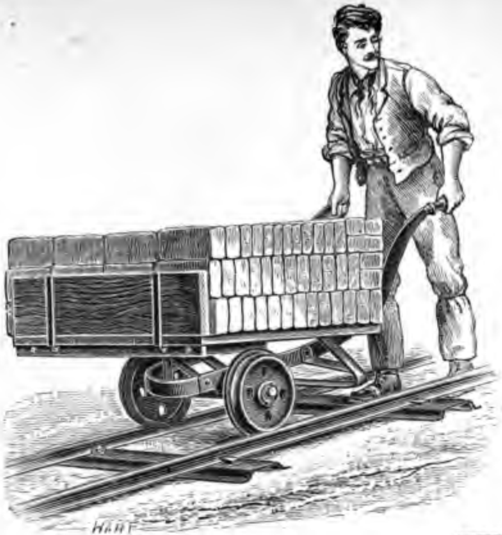
First, I must briefly describe the general nature of the country through which we had to lay our trams, in order that the actual cost of construction, which follows, may be better understood. All the sites for our factories were selected at various points along the existing Saõ Francisco Railway, the farthest being at a distance of about seventy miles from Pernambuco. They were connected with this railway by sidings of the ordinary gauge, and the sugar, when manufactured, was sent off by trucks to the coast for shipment. I propose to take three of these sites as a fair sample of the country:—

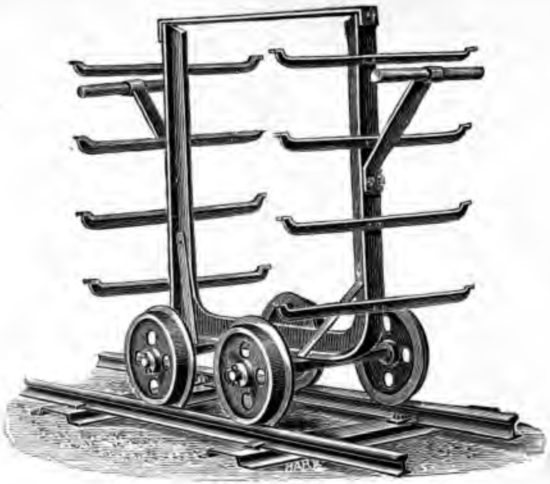
(1) *Cabo.*—Here we had a fairly easy country to deal with, gently undulating or quite flat, no forests to cut through, and only an average amount of bridges and culverts to build.

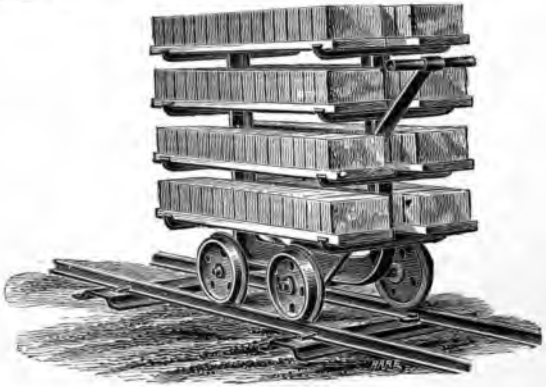
(2) *Coyambuca.*—The country here is much more difficult. It consists for the most part of round-topped hills, three to four hundred feet in height, with streams and rivers flowing at their base. These hills are often cleared, and cultivated with sugar-cane half way to the summit, the top being clothed with trees of tropical growth. The best line for the trams here is difficult to ascertain, and many trial sections and cross-sections must be taken before it can finally be settled. In many cases only one possible pass existed through the chain of surrounding hills, and to take a good section over such rocky summits without the aid of a plan of the country has often proved a difficult task. We were restricted to gradients of 1 in 40, but only made use of one so steep in rare instances in order to cross some mountain pass that we found after many trials could be crossed in no other way, except by rock cutting 10 to 20 feet deep, and this we avoided as much as possible. No gradient steeper than 1 in 80 was the rule, and curves of 20 chains radius.

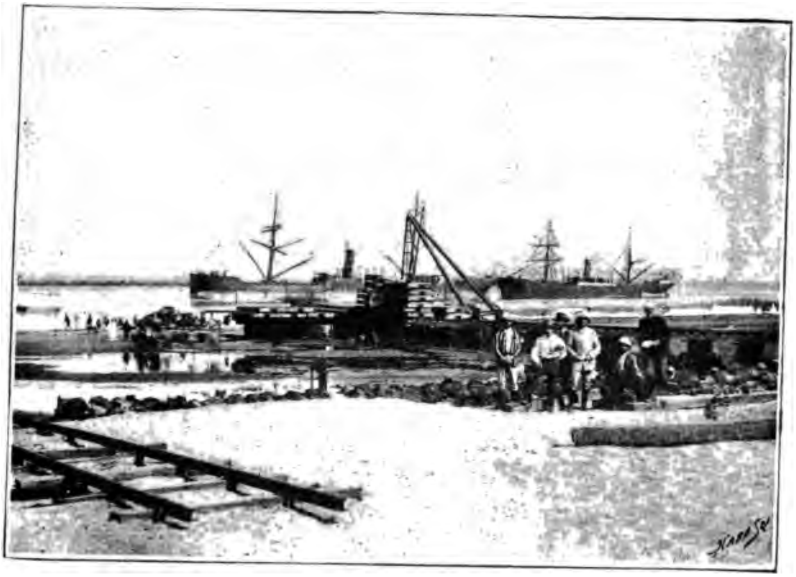
(3) *Agua Preta.*—The country here much resembles that at Coyambuca, except that the forests to be cut through were more dense and the undergrowth more impenetrable. There was also one river of some magnitude, entailing a bridge of two 30-feet spans to be crossed.

The gauge of our tram-lines was 2 feet 4 inches, and the









finished formation width 8 feet, in cuttings and banks. The lines were unfenced, but no inconvenience was found on that account, and no accident occurred in my experience.

The following is a summary of the cost, so far as construction is concerned, of the tram-lines to which I have alluded, and is made from the actual payments to the contractors on certificates made by myself:—

Cabo (5½ *miles*).

Let at 750 milreis per kilometre	£685

Coyambuca (6¾ *miles*).

Earthwork, 44,013 cubic metres	£3674
Forming, 1020 lineal metres	44
Quarrying stone, 568 cubic metres	198
Building bridges, 106 „	61
	£3977

Agua Preta (5¼ *miles*).

Earthwork, 26,863 cubic metres	£2102
Forming, 541 lineal metres	24
Quarrying stone, 595 cubic metres	207
Building bridges, 388 „	223
	£2556

Summary.

Cabo	5½ miles	£685
Coyambuca	6¾ „	3977
Agua Preta	5¼ „	2556
	17½ „	£7218

showing an average cost of £412 per mile; and I think this may be taken as a fair average estimate in almost any part of the world.

The following is a table of prices for labour and material at that time (1883) obtained in Brazil, which I append for purposes of comparison:—

Cost of Labour and Material in Brazil (1883).

(The paper milreis are worth nearly 2*s*.)

Description.	Rate.	Remarks.
	Milreis.	
Labourers	1,100	Per day of ten hours.
Artificers	3.200	„ „
Earthwork	0.900	Per c.m. (lead of 400 yards).
Quarrying stone	4.000	„ (includes powder).
Broken stone	1.500	„ (2-inch ring size).
Brick-making	22.000	„ without wood.
Tile-making	30.000	„ „ „
Stone masonry	15.000	„ building and quarrying.
Platelaying	700.000	Per kilometre, laying and ballast.
Getting sand	2.300	Per c.m. with transport.
Dressing logs	0.050	Per square foot, for squaring.
Pitch pine	10.000	Plank, 20′ × 9″ × 3″.
Native logs	30.000	Price of tree in forest.
Rafters	0.500	Each, 20 feet long, 3 inches diam.
Cement	7.000	Per barrel at port.
Planks (rough)	30.000	Per dozen, 20′ × 14″ × 1½″.
Concrete	18.000	Per c.m. for labour and material.
Forming	0.500	Per l.m. under 0.40 cm. of cutting.
Bricks	5.000	„ unburnt.
„	12.000	„ burnt.
Wood	4.000	Per load, for brick-burning.
Bullock hire	6.000	Per day, team of four and driver.
Brickwork	22.000	Per c.m., labour and material.
Native sleepers	2.500	Each, 9′ × 9″ × 5″.
House rent	15.000	Per month, small log hut.
Clerk of works	100.000	Per month, without keep.
Servant, European	60.000	„ with board and lodging.
„ native	30.000	„ „ „
Horse keep	25.000	„
Horses	150.000	Each, for riding.
Native ganger	75.000	Per month (one for ten men).
Interpreter	100.000	„ without keep.
Offices	100.000	„ at Recife.
Engineer	8000.000	Per year, and travelling expenses.
Fitters	3000.000	„ and return passage.
Travelling	100.000	Per month, average.
Medical attendance	5.000	Per visit, without medicine.
Freights	16.000	Per ton from England.
Import duties	—	Half English value of goods.

Cost of Labour and Material in Brazil (1883)—continued.

Description.	Rate.	Remarks.
	Milreis.	
First-class passage	250.000	Each, to or from England.
Second do.	200.000	" " "
Engine oil	4.000	Per litre.
Bread	0.200	Per loaf.
Meat	0.500	Per kilo. for beef (2 lb.).
Wine	35.000	Per cask (65 bottles).
Beer	1.000	Per bottle.
Chickens	1.000	Each.
Eggs	0.640	Per dozen.
Coffee	1.000	Per kilo. (2 lb.).
Sugar	0.400	" "
Mutton	0.200	" "
Boots	10.000	Per pair (last 4 weeks).
Clothes	30.000	Per suit (white).
Letters	0.200	Postage to England.
Telegrams	5.000	Per word to England.

I think a careful study of these prices will show that both labour and material are dear in Brazil, and, therefore, £412 a mile, which our tram-lines cost us in the three cases selected, is rather more than an average cost in most parts of the world; especially as in these cases one-third of the distance was fairly easy country, while two-thirds was exceptionally mountainous and difficult. I therefore propose to take £400 a mile as a fair average cost in any part of the world.

My estimate, then, for a single line of railway, 2 ft. 4 in. gauge, 8 feet formation width in cuttings and banks, with steel rails 14 lb. to the yard, would be as follows:—

Estimate (per Mile).

	£	s.	d.
Earthwork, including all bridges and culverts	£400	0	0
Setting out line	10	0	0
22 tons of steel rails at £14, freight included	308	0	0
2000 sleepers at 2*s.*	100	0	0
600 pair fish-plates	20	0	0
15 cwt. spikes	7	10	0
Switches and crossings	20	0	0
Laying and ballasting	120	0	0
Signals	5	10	0
One-tenth of a station	50	0	0
Sidings	14	0	0
Turn-tables	8	0	0
Total cost per mile	£1063	0	0

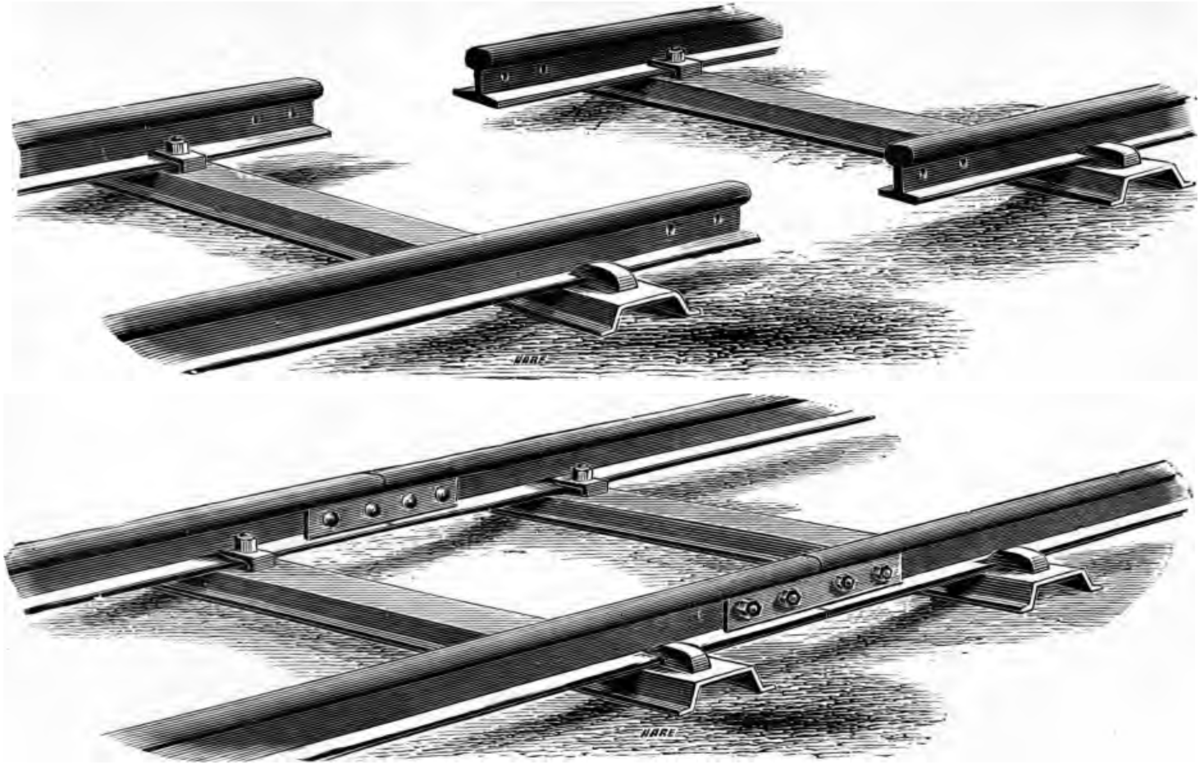
Equipment—Rolling Stock (per Mile).

	£	s.	d.
One-tenth of an engine	£40	0	0
Four railway trucks	32	0	0
One platform truck	6	0	0
Two passenger carriages	60	0	0
One brake van	30	0	0
One-fifth of a trolly	2	0	0
Tools, plant, &c.	30	0	0
	£200	0	0

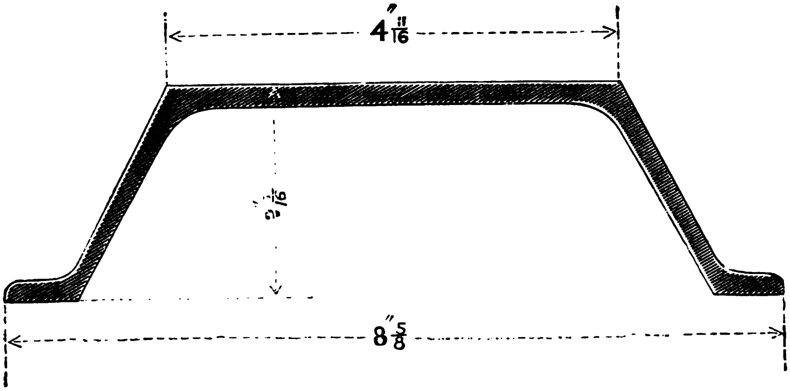
Our cost per mile is therefore—

	£	s.	d.
Construction	£1063	0	0
Equipment	200	0	0
	£1263	0	0

I will assume that the exploration of 100 miles is to be undertaken. The capital required, based upon these estimates, would be £126,000. Add £13,000 for interest for two years on capital during construction, at 5 per cent.



ROLLED STEEL SLEEPERS.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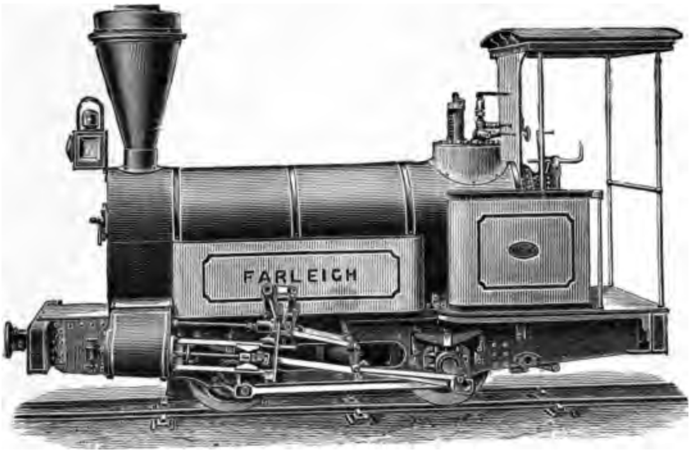
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per annum, and we have a total capital expenditure of £139,000, or say £140,000, for which we have 100 miles of a good permanent narrow-gauge railway, well furnished with suitable rolling stock for a considerable traffic, and with stations every ten miles, siding accommodation, &c.

After two years for completion of the 100 miles, the following would, I think, be a fair estimate for the working expenses:—

Working Expenses.

Maintenance, at £5 a mile	£500
Cost of ten stations (three men at each)	1600
Salary of traffic manager	600
„ engineer	600
Clerks and offices	500
Engine-drivers and stokers	350
Fitters and repairs	180
Pumping expenses	200
Coal	750
Other stores	150
Repairs to rolling stock	200
Telegraph expenses	400
	£6030
Add for contingencies	470
	£6500

I put, then, the annual working expenses at £6500. To meet this we should have the traffic receipts for goods and passengers. Omitting the latter entirely, if only 150 tons a day were carried over the line, at an average charge of 10*s.* a ton for the 100 miles, we have (taking 300 days a year) 45,000 tons at 10*s.*, or an annual revenue of £22,500, which, deducting £6500 for working expenses, leaves £16,000 net profit, equal to 11½ per cent. on a capital of £140,000.

Our tram-lines in Brazil were fully capable of carrying this quantity of sugar-cane per day to supply each factory. In fact, 75 two-ton trucks will take it, and these 75 trucks can be easily divided into one train each way over the 100 miles per day which, with easy curves and gradients, the little engines are quite capable of doing. The passenger traffic is more difficult to estimate, and must, of course, depend on locality and other circumstances; but taking only twenty people a day to travel the whole distance, and pay 10*s.* for their fare, we get £10 a day, or say £3500 a year, so that £20,000 a year is a reasonable estimate for available income, after paying working expenses, even when the 100 miles is first opened.

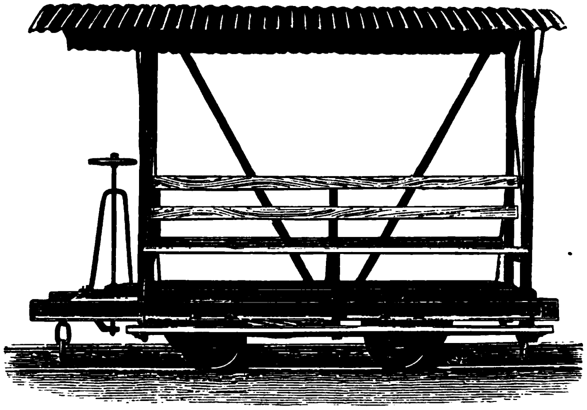
This is, however, only the first step in the scheme I am advocating of exploration by means of light railways. Having got the first 100 miles with ten stations in working order, I will now suppose a second section of the same length to push still farther into the interior is decided on. As the line already established is paying its way so well, it will not be difficult to extend the capital to construct the new section, but for this purpose we shall require only the £400 a mile (£40,000) as given in our first estimate for earthwork, bridges, and culverts, and £190 a mile (£19,000) for laying and ballasting, stations, signals, &c., or in all £59,000. All the permanent way, rolling stock, and plant on the first section would be released and conveyed to the front, to be relaid and utilised on the new section. The traffic on the first section having increased beyond the carrying capacity of the light railway, the conversion of this into one of the ordinary type would simultaneously proceed by widening the formation, bridges, and culverts, and laying either a single or double line with heavy metals, as the traffic developed might seem to require, sufficient engine power and rolling stock being of course provided.

Most of this work could gradually proceed, such as widening of banks and cuttings, during the running of the traffic on the narrow-gauge system, so that, when that plant was removed to the formation prepared for it at the end of the section, but little interruption to the traffic would occur—merely the time occupied in relaying with heavier permanent way. Simultaneously the new section would be ready for the light metals and rolling stock when released, which would always be available for further extensions.

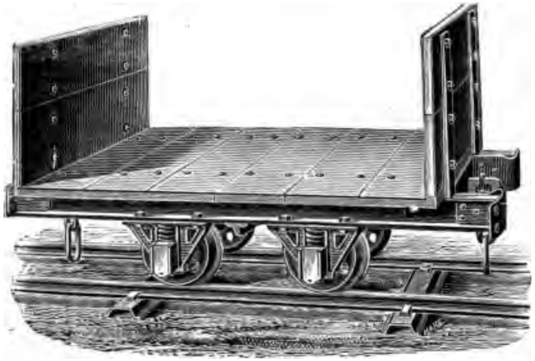
At the expiration, then, of two years from the time the exploration is first decided on we should have this result—viz., 100 miles of railway laid down in working order, fully equipped, and paying 14 per cent. on the original capital, 5 per cent. having been already paid during construction; a further section of 100 miles in progress, the cost of which will be only £59,000 when completed; and the original section ready for the wider gauge, heavy rails, and rolling stock.

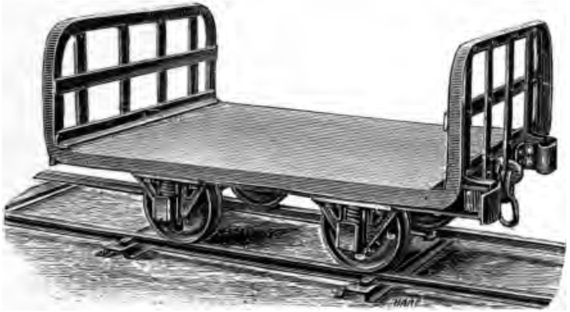
It will therefore be seen that, though the cost of 100 miles complete is £140,000, the cost of the 200 miles is under £200,000, or £1000 a mile. But further capital will be needed, or part of the profits utilised, for relaying the first section with heavy metals and for providing rolling stock, &c.

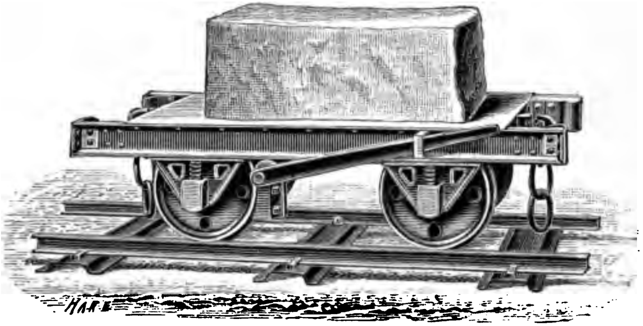
I purposely omit any estimate for conversion from narrow to ordinary gauge, as this would be on a scale to meet the requirements of ascertained traffic. The line might be single, or it might be double either for the whole or a portion of its length. The rolling stock would be more or less as the case required, and the same would apply to stations and siding accommodation. Any capital so expended would become at once highly productive capital, and, whether large or small, may be entirely omitted from our present calculations.



OPEN PASSENGER CAR.







CHAPTER III.

WE have seen that for establishing these light railways in thorough working order and ready to earn a dividend, in any part of the world, I estimate the cost at £1000 a mile. Now, 1000 miles of such a railway will carry civilisation very far into the interior of any unexplored country on the globe, and one million of capital so expended (very shortly to be productive, as already shown) compares favourably with the millions spent in expeditions for the purposes of exploration in the past with but little result, at least of a practical nature.

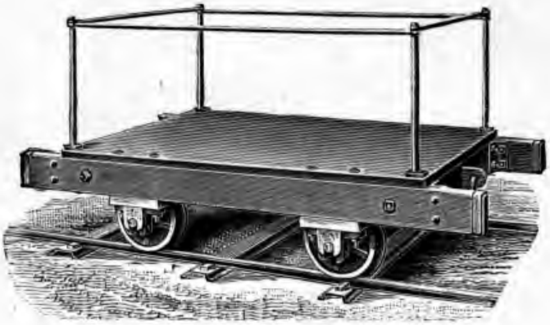
If we take a line across the widest part of Africa, about 15° north of the Equator, from the port of Aden on the Red Sea to Cape Verde on the Atlantic, across the Desert or Great Sahara, we find the distance, as laid down on Mercator's Projection, is under 4000 miles. Surely four millions to make a railway from ocean to ocean would be as nothing compared to what the numerous expeditions to which we have referred have cost in the last 400 years. Again in South America, on a line 10° south of the Equator, from Pernambuco on the West coast to Port Payta on the Pacific Ocean, a line which would open up the unknown regions in the very heart of this vast continent is short of 6000 miles, and six millions is no very large sum to accomplish the great results which would follow—viz., the spread of Christianity, commerce, and trade, and the establishment of law, order, and settled government.

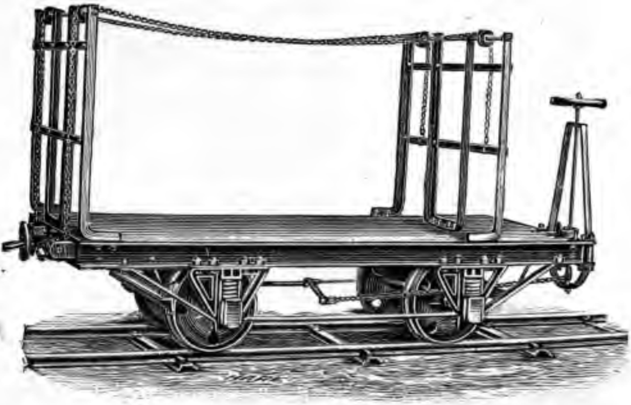
As regards the rate of the progress which could be made in the construction of such railways as we are considering, and which would afterwards develop into the main trunk lines, opening up, with their branches, the countries of the world in every direction, a few words must be said.

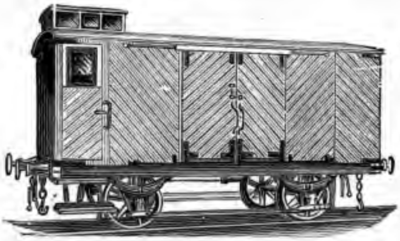
Passing from large matters to small (and every great ending had a small beginning), I again take my data from our Brazilian tram-lines, and what we found could be there accomplished.

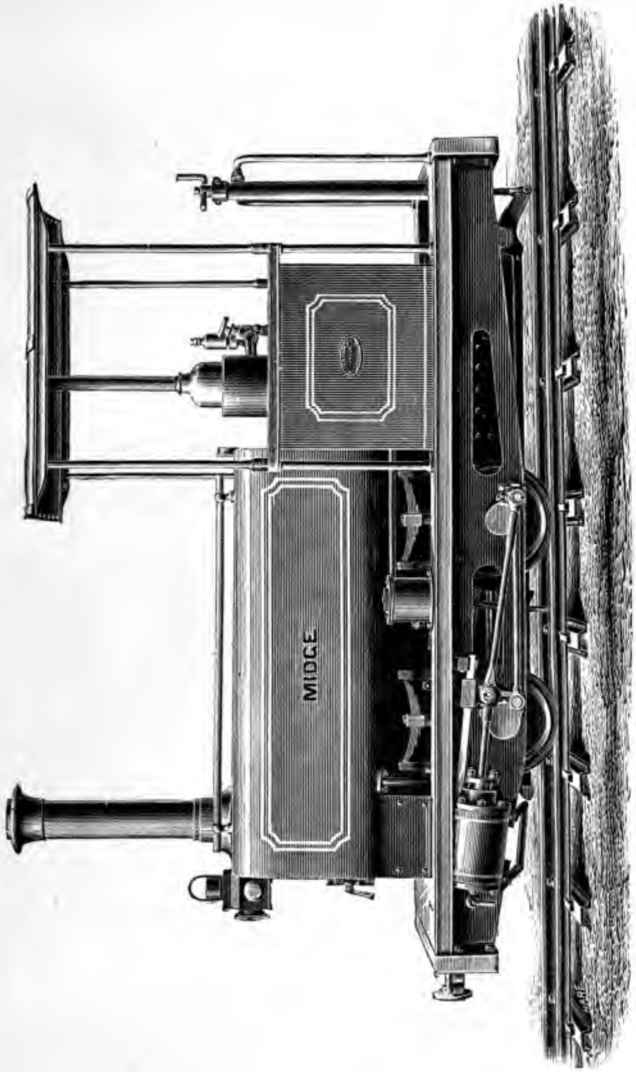
As I have already said, we were but a small party of engineers. In fact, as far as the work of setting out and locating the tram-lines was concerned, there were but four of us—viz., a brother engineer (with whom I had had previous experience in railway work in Bulgaria), myself, and two pupils, who became of service at the end, but who had at first to be instructed in the mysteries of surveying and levelling. We had no maps or plans of the country on which to lay out our railways, nor did we attempt to make any, but our plan of operations was as follows :—

Having established ourselves either in such a house as could be obtained in the vicinity of one of our proposed factories, or in a tent, as the case might be, we proceeded to explore the country for some miles on horseback in the direction which it was intended our trams should follow, making careful observations as to the features of the country, what valleys it appeared easy to follow, and especially what passes or natural outlets appeared to exist in the chain of surrounding hills which we could surmount, not exceeding the limit for gradient and radius for curves, and with as light a section as the circumstances of the case would allow. We noted also what rivers and streams must be crossed, and where bridges might be avoided by diversions of water courses. Also as to the probable nature of soil, and what stone and sand could be obtained for bridge-building and ballasting.








MIDGE

In our case, of course, the fertility of the land had to be considered for the production of sugar-cane, as, when the maximum quantity of 350 tons a day which one factory was capable of crushing was secured, no further extension of the railway for that particular factory would be requisite. It will be seen, therefore, that these explorations had in the first instance to be carefully considered, and that time so expended was not time wasted.

Having, then, decided upon the best practical route, the next thing was to set out the centre line and take the section and cross-sections where required. Commencing from the plateau on which the factory was arranged to be built, we set out the centre line, following as nearly as possible the route determined on, with pegs driven at every chain. I had with me a transit theodolite, but used it rarely, except for running long straight lines or putting in curves where the tangents could be chained out and the angle of intersection taken without clearing bush and forest, which added much to our labour. We therefore cleared no more than could be avoided till we came to make the formation, cutting down only a narrow path along the centre line of such undergrowth and trees as came in our way in ranging our poles. For this purpose we had four or five natives going ahead of us, armed with axes, &c., who would cut down in the direction we indicated, and drag the branches and trees to one side.

We then set out our curves, usually by offsets—

$$\left(\frac{c^2}{r}\right)$$

from one end only, setting off again—

$$\left(\frac{t=\frac{c^2}{r}}{2}\right)$$

for the next straight line we were able to run.

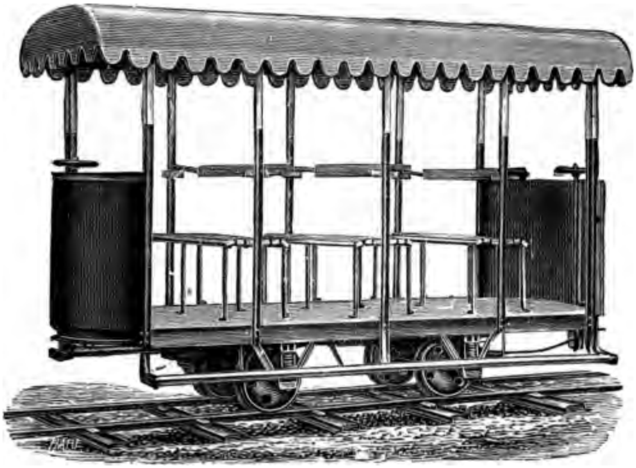
Of course, we often had to alter our radius after trying one round a portion of a curve, but with a little practice were soon able to judge what radius would suit; but in spite of all difficulties, such as a tropical sun, tropical vegetation, the difficulty of making our men understand us and their duties, to say nothing of snakes and other poisonous creatures, and insects, we were able to make a fair rate of progress, and on an average would be able, if the country was fairly favourable, to set out some 3 or 4 kilometres after a long day's work, then jump on our horses and gallop back to our tent, to enjoy the bath, food, and rest of which we stood so much in need. We never set out more than a few miles of the trams in this way without taking the section, in case we should find any alteration or diversion requisite to secure greater economy in construction. The levelling was a quicker operation, the track having been cleared. Plenty of bench marks were left for the purpose of running check-levels.

In this way, after perhaps a fortnight's hard work, some two or three miles, according to the nature of the ground, would be set out, and the section and cross-sections, where necessary, taken.

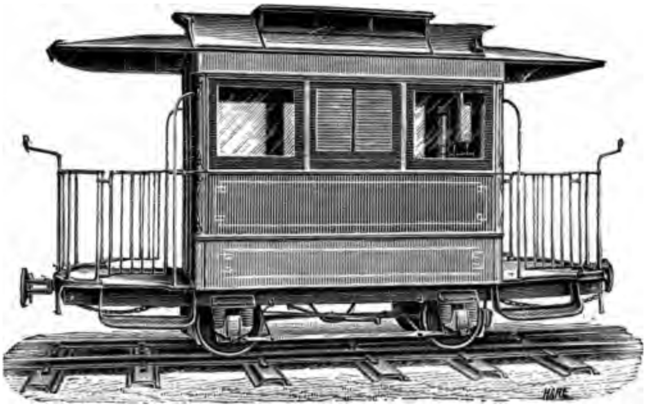
Our party would then return to head-quarters at Pernambuco, where we had established our offices, and where such supplies as we required for taking up the country could be obtained.

The section had then to be plotted, which was done to a scale of 2 chains to an inch horizontal and 20 feet to an inch vertical, and the gradients were next put on, 1 in 80 being as a general rule the steepest incline admissible.

For the purpose of light railways for exploration I do not advocate either sharp curves or the use of steep gradients, although I am aware that by Fell's and other systems such railways have been successfully laid down. Our little engines could haul on the level 60 to 70 tons, but on gradients of 1 in



OPEN PASSENGER CAR.



PASSENGER CAR.

50 the same engine could take only 15 tons, thus seriously affecting the carrying capacity of the line.

Another reason against steeper gradients than 1 in 80 for exploration railways is that, by adopting a good section in the first instance, no alteration need be made in converting the narrow to the ordinary gauge hereafter, and merely the necessary widening of the cuttings and banks would be required, the original formation being retained.

Having, then, settled the gradients, the height of cutting and bank were written down at each chain, and, a tracing having been made, the section was ready to let to a contractor, at prices already given.

All this work would occupy a few days, and we were then ready again to start up country, and commence on a fresh section. When the contract for a section was once let, we found the rate of progress was dependent on the speed with which we could set out the lines, and supply the section to the contractors. We had one, a Norwegian, a most energetic and pushing man, with a thorough knowledge of the country, and who had plenty of plant at his disposal, and could command any quantity of such labour as was available. Our other contractor, in a smaller way of business, was a Portuguese. At any rate, we found that, in the construction of the tram-lines, they followed very close at our heels, and unless some delay occurred, by a bridge of larger dimensions than usual having to be built (which of course also we had to design), it was as much as we could do to keep them and their gangs fully employed.

The laying permanent way and ballasting was even a more speedy operation than preparing the formation, so that the speed at which the tram-lines could be laid out regulated the speed at which they could be constructed.

As I have said, however, we were but a party of four engineers in all, and the duties of laying down the tram-lines were not the whole of our duties. At each of our sites we had the plateau of 5 or 6 acres to level, and prepare for the erection of the factories, large buildings 360 feet long. Then we had the concrete foundations to put in for the walls, and for the cane-mills and heavy machinery that had to be erected. We had also all the bricks and tiles to make and burn, and all roofing, doors, and windows to get made. For the landing and erecting the sugar machinery we had mechanical engineers and fitters to assist us. Besides all this work, my colleague's time, especially, was much taken up in carrying on negotiations with planters as regards supply of cane, purchase of timber, stone, clay for brick and tiles, the selection of sites, and many other matters too numerous to mention, so that it was only possible to devote a comparatively small portion of our time to the tramroads. Then there was the designing and laying out of bridges, the general superintendence of the work in progress, and the measurement of the contractors' work. This last fell entirely to my share, and was done at the end of the month on each contract. It is from these certificates, of which I have copies, that the cost of the tramways is here given, and is therefore reliable. These measurements were taken with a tape on the ground, and, when several contracts were going on in different parts of the country at the same time, occupied several days in each month, and involved many hours on horseback to get to the different places, so that it will be seen there were several causes, in our case, to prevent the trams being constructed as quickly as I am sure might be done with a sufficient staff of engineers and trained assistants, and nothing but the pushing forward of the railway to occupy their attention.

The staff, I think, should consist of eight engineers and four assistants, trained to the work, besides native labourers to clear the bush, carry instruments, poles, pegs, &c.; and horses for riding would also be required.

Their duties, I think, should be thus distributed:—Two (with an interpreter if necessary) would ride in advance to settle the general direction and make all inquiries possible. Two more with sufficient assistants would follow, staking out the absolute centre line, and, of course, with them would go the labourers to cut and clear the scrub. Next would follow one man and a good staff man taking the section, and a sixth engineer would be engaged in running check-levels and taking any cross-sections required. The level books would be sent off to the two remaining men, who would be left at head-quarters in the drawing office, and whose work would be plotting sections, fixing gradients, designing all works, such as bridges, culverts, stations, &c. They would also let the contracts and measure up contractors' work monthly. These duties would be very important, though less laborious than those of the engineers engaged in field work. By this subdivision of labour the contractors would not be stopped for want of the line being set out quickly enough and sections supplied, and I can see no reason why, in this way and by such a system organised as I have endeavoured to describe, on any single light railway in any country from 6 to 10 miles could not be entirely completed in a week. This would mean, we will take it, 400 miles a year, and, at this rate of progress, in a very few years those long lines of railway we have alluded to, traversing the great continents of Africa and South America from ocean to ocean, would become accomplished facts.

Before the ten years elapse to complete this nineteenth century what a transformation would have taken place! With our fast steamers to land us at the ports, and with the railways to carry us at the rate of 20 to 30 miles an hour into the interior, there would be no place on the habitable globe that would not be within easy reach of our missionaries, our traders, and our men of science. To visit such places would be no difficult and dangerous task, as at present, so long as direct communication was kept up with our own country. All the comforts, and even all the luxuries, of civilisation would penetrate to these remote regions, and to live for a time in these countries would be no banishment, no life of privation or of danger and suffering.

It is true that exploration even at the rate of 400 miles a year may seem slow to some of our great travellers, but to push through a country at this speed has, in many instances, been found an impossible task, owing to the difficulties and dangers encountered. Provisions have failed, sickness has overtaken the traveller with no medical aid or stores at hand, and delayed his journey for months, and in many instances delayed it for ever.

We cannot read the interesting narratives of any of our great explorers, or the accounts published of missionary efforts, without recognising these facts. These brave and good men have died by thousands in their noble endeavours to spread Christianity and civilisation for the want of that assistance which communication with their fellow-men would have provided. If an organised system prevailed of laying down these light railways by the East Africa or by any other exploration company in any part of the world, the exploring party or the missionaries or the trader need never penetrate beyond a few days' journey from the most advanced station of the railway, and could always fall back upon that station for relief when difficulties, sickness, and danger approached.

I have therefore endeavoured to establish these points:—

(1) That light and inexpensive railways are the cheapest mode for exploration.

(2) The result is more permanent and satisfactory.

(3) It is as quick, if not a quicker method for the establishment of Christianity and civilisation.

(4) That capital invested in such railways becomes in a short time productive and remunerative capital.

It remains now to consider in what parts of the world such railways may be employed with success.

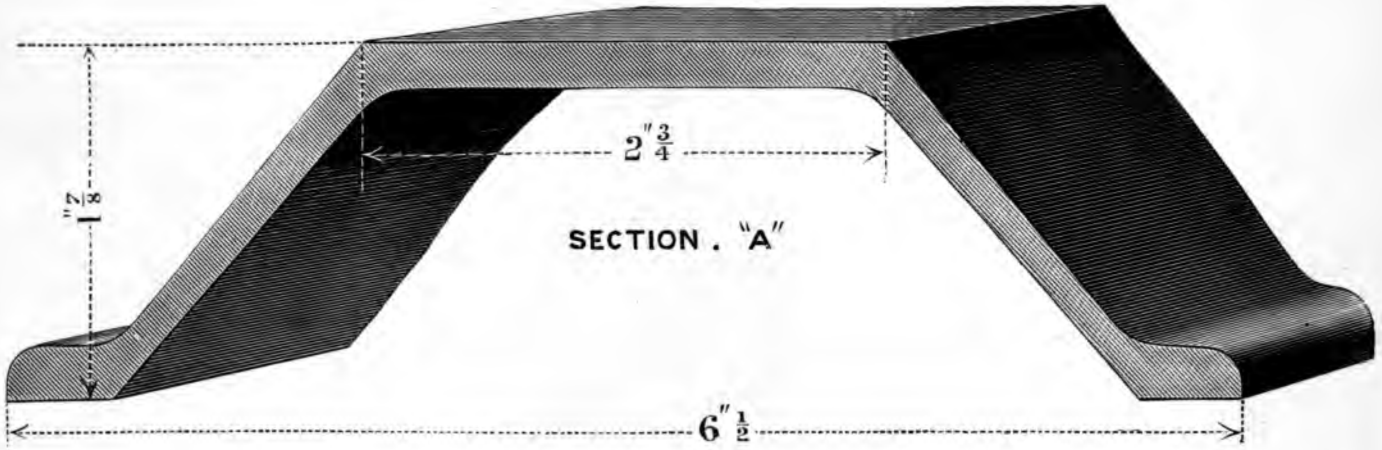
I should like to say a few words on this subject, first, in connection with Equatorial Africa and Mr. Stanley's last expedition. It is evident, from the most interesting account of his adventures and his travels, fully confirmed by that of other distinguished men who have explored very far into the interior of the Dark Continent, that the difficulties they have all encountered are not such difficulties as need discourage the engineer or stand in the way of railway enterprise. On the contrary, their accounts of the physical features of the country they traversed go to show that railway construction is not only feasible, but that easy routes could be found, crossing great plains and deserts, and following the estuaries of the rivers, to those great lakes now so familiar to us by name. The difficulties that these travellers so successfully overcame, but to which others in former times have succumbed, would all be swept away before a gradually advancing railway. Each station as it was secured would form a new point of safety in a hostile and barren land—a new resting-place from which to advance, and on which, when necessity arose, to retreat, and a new depôt for the supply of all medical and other stores essential for the support of human life. It is the extending researches too far from the reach of civilisation that creates the perils of these expeditions, and it is on this account that I maintain that, as an engineer by means of these railways carries civilisation with him, the dangers would vanish at his approach.

I am not myself acquainted with any part of Africa, and such information of the country as I have is derived entirely from the published accounts of travellers; but I am sure I am correct in saying we have no information from them to show that any exceptional obstacles to the laying down a complete system of light railways, in any part of the country explored, are known to exist. We read, no doubt, of vast swamps difficult, and perhaps all but impossible, to cross, but these could probably be avoided in setting out the railways. We also read of forests so thick and tangled that Mr. Stanley and his followers spent weeks in making but a few miles' progress in the partial darkness produced by the matted growth overhead; but even this would yield to the gradual but sure progress of a railway, bringing to the attack as it advanced, step by step, more labourers fully prepared with all requisite tools and modern appliances to wage war against Nature, till at last, with a shrill scream of triumph, the little engine would rush through what was once an impenetrable and trackless forest, and the victory would be won.

For one man, or for a dozen men, to stand alone, far removed from all human assistance, and without the means of supporting life in such an awful position, however great their pluck and determination, seems all but impossible; but with the engine close at hand, and under control, to bring up supplies and assistance as required, the aspect of affairs is changed, and confidence may take the place of despair.

Even then, in the heart of Africa, through such countries as we have had described to us, I venture to assert that light railways, differing very little from what we have been considering, could be constructed in Equatorial Africa for £1000 a mile, and at the rate of 400 miles a year.

CLEARING FOREST.


1" 7/8
2" 3/4
SECTION. "A"
6" 1/2

Possibly rolled steel sleepers, owing to the insects which soon destroy timber in tropical countries, might be used, but this will not materially affect our cost, steel sleepers and fastenings costing £228 a mile, instead of £128 as in our estimate, or increasing cost per mile to £1100. Steel sleepers are, however, both light and durable, the life of them being given at forty years, so that the first cost would soon be recouped. The section given is suitable for carrying 14 lb. rails, laid to a 2 ft. 4 in. gauge. It is 4 feet long, of rolled steel, and weighs 30 lb. 1920 sleepers per mile are recommended.

In considering recent explorations in East and Central Africa, and applying what we have learnt from them as to the suitability of the country for establishing a complete system of railways, we must, I think, be struck by the fact that the produce from which any future traffic to support those railways may be anticipated is of a light rather than a bulky character. Mr. Stanley has told us of the great value in ivory he was obliged to leave behind him owing to the impossibility of obtaining transport to convey it to the coast. He and others have told us of natural products in abundance, all of great value, but not one of which is of a bulky nature; and for this reason it would seem that, at any rate for an export trade, for some years to come light rather than heavy railways would best meet the requirements of the country. At present heavy railways would not pay for the cost of construction, the traffic to be anticipated being of too light a character to support them unless the freights charged were very heavy in proportion to the weight carried. No doubt, as time went on, and the land was brought under cultivation, and the mineral wealth of the country became developed, traffic might be created for ordinary lines; but when that time arrives, as I have shown, the light railways can be converted to meet the new requirements. From what we know of this country, then, we may say that at the present time ready means for light transport, rapidly laid down and for a small cost, is exactly what is required, and might perhaps suffice for some years to come.

CHAPTER IV.

We now come to the point which has recently given rise to so much international jealousy in relation to this country—viz., whether the influence of Great Britain or the influence of Germany is to preponderate in Eastern and Central Africa. Territorial maps are published showing lines of demarcation, and what zones of country are under British and what under German rule, and other parts which are still bones of contention, and respecting the possession of which it is sometimes feared that complications may arise between the two countries. There are, however, no doubt, many thousand square miles of territory which acknowledge only British rule, and if our railways were first laid down in such parts, it would follow that, being first in the field with a practical scheme, the waverers would soon give in their allegiance to us, and our influence predominate through this country as it has done in the past in so many quarters of the globe. We should in this way gradually arrive at a peaceful settlement of this vexed question through the will of the inhabitants of the country themselves, and this satisfactory settlement would be brought about, not by conquest and annexation, and not by the arts of diplomacy, but by the combined and united efforts of explorers and engineers working hand in hand in the cause of civilisation and progress.

The battle between white and native rule would soon cease when the practical advantages of the former were in this way demonstrated. In fact, it may be said that already, owing to the protection of the trade by caravans under the auspices of Great Britain, the Sultan of Zanzibar is willing to entrust his customs and his revenues to her care, recognising the fact that British subjects have established the caravan stations, and by their means brought the natural wealth of his country to the coast. Even now the annual value of india-rubber alone exported is stated to be £60,000. Till four years ago the Sultan of Zanzibar held an unquestioned right over all the interior of Central Africa, and, as a proof of his appreciation of what British traders had done by the caravan routes and stations for his country, he then offered to our Government sovereign administration of his dominions, and a lease of seventy years of the whole of his customs and revenues. The offer was then declined by the Imperial British East African Company, owing possibly to German claims being advanced, and spheres of British and German influence were then proposed and sanctioned by the Great Powers at Berlin in 1886. These are matters of history, and quoted here only to show that the country which first establishes lines of communication will be the country which will eventually govern the destinies of the great continent and traffic in the land.

The caravan routes established by British enterprise are but the forerunners of the railways of the future, and in proportion to their establishment by the one nation or the other so will her sphere of influence become more or less.

It has been denied by some that discoveries and explorations form any claim to Eastern Central Africa. If they did, we should undoubtedly be the country to whom the prize should be given. It would not, however, be disputed that, if we went a step farther and added to our researches the employment of our capital in establishing systems of railways, we should thereby make our claim good. I do not think it can be said that our objects and those of our rivals are identical. No doubt the two countries are actuated alike by good motives, such as abolition of the slave trade and the spread of Christianity. The motives of the King of the Belgians in devoting a large portion of his life and fortune to these good objects are beyond a doubt entirely those of a great philanthropist, and these motives are shared by both England and Germany; but, at the same time, we have ulterior objects, differing in the two cases in very important respects. Our objects would seem to be developing the trade and resources of the country for the purpose of finding fresh markets for our own produce and home industries, while those of Germany are entirely for colonisation and as an outlet for her increasing population. There can be but little doubt which of these objects is the most likely to command success, or which would naturally commend itself to native chiefs and rulers.

To put it clearly, Would they prefer the surplus population of Germany to impoverish and overrun their land, or would they prefer the employment of British capital to supply the demand for manufactured goods which the rapid development of the country would create? The question was, I think, answered when the Sultan of Zanzibar offered a lease of his customs and revenues to Great Britain.

A still further objection to the German idea of colonisation exists in the fact that the climate is unsuited to white men. All travellers to the country agree on this point, and it is an objection to which no remedy exists. Explorers and engineers may do much by united effort to create trade and commerce, establish quick communication by railways from place to place, bring into the market such natural productions as are of value, and supply in exchange manufactured goods of which the inhabitants stand in need, but they can do nothing to alter the climatic conditions, and these are unfavourable for Europeans, and must remain so.

To make an attempt to ameliorate the condition of the native races and raise their standard in the social scale in the country to which they are suited by nature is surely wiser than to import Europeans to colonise and overspread a country for which Nature has not fitted them, and where deterioration must take place, even if able to live at all under the transplanting to a soil unsuited to their constitution.

These, no doubt, were some of the reasons that caused so much hostility and opposition to the German East African Company on the part of the natives, and caused Lieutenant Wissmann's expedition to become necessary. As for the Imperial British East African Company, Mr. G. S. Mackenzie had no similar troubles with the native tribes.

In considering East and Central Africa as a field for the construction of light railways, I have wandered somewhat from the path, but the object of my digression was to endeavour to show that the disunion and rivalry which unfortunately at this time seem to bar the way to progress would cease to exist if this country were now to push forward in that portion of Africa in which her sphere of influence is indisputable. Were capital expended in railway enterprise there, the unoccupied territory would soon, by the will of the people, be ours to deal with in a similar way, and British rule in East and Central Africa would be accomplished.

Four hundred thousand pounds spent annually on four hundred miles of narrow-gauge railway in this country would soon confirm the native chiefs in the opinion they have probably already formed of what results British capital and British energy are capable of producing; and, as we have seen, this capital would very shortly become productive.

I should perhaps apologise for writing of a country of which I have no personal knowledge, and where I have derived my information entirely from the researches of others. I have, however, endeavoured to take up only those points of interest and those features which seem to apply to my subject, and to show how far what has been said by those who are familiar with the country justifies me in considering it as one suitable in all respects for the construction of a system of light narrow-gauge railways which may hereafter be gradually converted into permanent railways, and perhaps form the main trunk lines of East and Central Africa of the future.

In answering this question, then, in the light of the experience of others, I think we may say there are no insuperable objections; on the contrary, there is much in favour of their construction.

We have learnt—

(1) That, from an engineering point of view, no insurmountable difficulties exist.

(2) That, at the present time the export trade consisting of ivory, india-rubber, gum-copal, cloves, cocoa-nut oil, seeds, &c., although of immense value, is not bulky produce, and is more suitable for light and inexpensive railways than for heavier lines.

(3) That if British ideas for the future development of the country are carried out, it is by import rather than export trade, and the establishment of a new market for our ever-increasing home manufactures, which in a few years will create traffic to justify the expenditure of additional capital to convert those sections of the light railway contiguous to the coast into heavy carrying lines, thus releasing the original light railway and rolling stock for pushing explorations into the very heart of the country.

And, lastly, that nothing would be so sure to win over to our side the native rulers and tribes which they govern, and thus give to Great Britain that supremacy to which her explorations in East and Central Africa have entitled her, than the immediate commencement of railway enterprise in those territories where her sphere of influence is undisputed.

Before taking leave of Africa as far as my subject is concerned, a few words must be said respecting British possessions in the South as a field for extending the present railway system at moderate cost on the narrow-gauge system.

The South African Republic, or Transvaal, manage their own railway system, all (including the Kimberley line) being, I believe, Government railways.

Cape Colony appears to some extent to have seen the advantage of the narrow-gauge system, and the saving that could be effected in the first cost thereby, and adopted a medium gauge of 3 feet 6 inches for their 1800 miles of railway, which cost them under £8000 a mile, and, as a result, they are able to pay a dividend of £4 18*s*. per cent. on the capital of £14,217,000 which their railways have cost them. This is, of course, a wiser policy to pursue than that alluded to in a former chapter—viz., the Varna and Rustchuck Railway in Bulgaria, on which I was engaged in 1870, and which (140 miles), as I have said, cost at the rate of £21,428 a mile, and the State obligations respecting that unfortunate railway have hampered that country ever since.

I am endeavouring to advocate a narrower gauge and cheaper railways still than the Transvaal railways at £8000 a mile. The Transvaal Republic, of course, manage entirely their own affairs, and I only venture here to make the suggestion that in the railway extensions now going forward in Natal, from Ladysmith into the Orange Free State, these little railways would prove, if adopted, of very great service. For branch lines also to feed already existing railways with traffic they are invaluable. Break of gauge, with the transshipment which it involves, is no doubt some objection, but when we consider that a charge of 4*d*. a ton will suffice to cover this expense, it will be apparent that this loss is as nothing compared to saving in original cost of construction.

It is an undoubted fact that branch lines made by the large railway companies on their ordinary principles have mostly resulted in loss, owing to outlay being so large in construction, in equipment, and in working expenses, and in order to ensure paying lines, where the traffic cannot be developed to an extent to meet the outlay, it is surely worth consideration if the outlay cannot be reduced to meet the traffic. Neither Governments nor shareholders will face a certain loss for the benefit of the community at large, and, if inexpensive railways are not adopted on an extensive scale, thousands of square miles of rich and fertile country in all parts of the world must remain undeveloped and contribute nothing to the wealth of nations.

Our British colonies in South Africa consist of some 250,000 square miles of country, for the most part rich in mineral wealth and in flocks of sheep and herds of cattle. On this vast area there are not at present 2000 miles of railway, or 1 mile to 125 square miles. On the high, flat table-lands in the interior a magnificent field for railway enterprise on an economical scale must exist, either for feeding the present railways with traffic, or for developing new districts now cut off from communication.

Passing to other parts of the world, we find the field for railway enterprise is practically unlimited. If we take the British empire in India, we find our railway system capable of enormous extension—not at present able, perhaps, to show a return upon an outlay of £40,000 a mile, which many of the lines there have cost, but sufficient to render a good and certain income on the more moderate outlay.

Some of our other British possessions in the East, such as Aden, Ceylon, Straits Settlement, Malay Peninsula, Hong Kong, and Cyprus, may be named as suitable fields for cheap railways, and I believe our statistical returns of the trade of all these countries would show that in one and all of them more railways are required, and that they would pay their way if due regard were taken to economy in construction by adopting the narrow-gauge principle at £1000 a mile at the first onset.

The British empire in America may be said to extend from the United States boundary to the Arctic Ocean, and here again must be an enormous field for profitable investment of capital in railway enterprise, if carried out on a scale proportionate only to such a country's present limited requirements.

In Newfoundland, with 42,200 square miles, and with already a large export trade, we hear only of 100 miles of railway, or 1 mile for 422 square miles of country.

Canada appears to have been the first country to recognise the rapid development of her railway system as the most powerful auxiliary to national prosperity, and we find she extended her railways from 6000 miles in 1878 to 12,700 miles in 1888. The Canadian Pacific Railway, 4274 miles long, was completed in 1885, and the time occupied in the construction of this splendid line, from the time of turning the first sod till it was opened throughout its entire length for traffic, was only four years and a half. It was therefore constructed at the rate of more than two miles and a half per day. When we consider the great achievement accomplished in laying down a first-class railway at the rate of 18 miles a week, the rate of progress we have given as possible of from 6 to 10 miles a week for our light narrow-gauge railways, in any average country, will seem to be well within the range of possibility. In fact, judging from this instance, it would seem that we might fairly have assumed four times this rate of progress. It is true that a large portion of the Canadian Pacific Railway traverses the great prairie country, where the formation would be easy, but, on the other hand, the Rocky Mountains had to be pierced, entailing thousands of yards of excavation through the solid rock, and the great rate of progress attained was due rather to the skill and energy of the engineers and contractors than to any exceptional physical features of the country in favour of rapidity of construction.

If we take Australia, the largest island on the globe, containing 3,171,078 square miles, we find only 9545 miles of railway, or 1 mile of railway for 332 square miles, and these railways are mostly coast lines, or running short distances inland from the ports and connecting the larger and more important cities. All the central portion of Australia is practically unknown and unexplored, and its natural resources lost to mankind, although the value of them to us is ever increasing with the steadily increasing population.

Here, then, is, within our own dominions, another large field for exploration and gradual development, and here the advantages of cheap railways cannot be over-estimated. We might go on to speak of such of our colonies as Queensland, with only 1931 miles of railway open, New Zealand, Tasmania, West India Islands, West Africa, Gold Coast Colony, Sierra Leone, &c., or British possessions in the South Atlantic, to show that light narrow-gauge railways could be constructed with advantage, to increase rapidly the prosperity of our own possessions in all parts of the world, and that there is plenty of scope for such profitable employment of capital on railway enterprise within the British empire and her dependencies for many years to come.

We need not, however, stop here. Concessions for construction of railways in foreign lands have been in the past, and will be in the future, placed in the hands of English capitalists and English engineers.

When engaged on our works in Brazil, I was much struck by the fact that all the important public works in that country had been accomplished by British enterprise. In Pernambuco, for instance, the railway (Saõ Francisco), the street railways, street tramways, and the gas- and water-works, one and all owed their origin to the same source. That wise and enlightened Emperor, Dom Pedro II., from the time of his accession to the throne in 1831 till the people declared in favour of a republic in 1889 and deposed him, had been unceasing in his efforts to promote the best interests of his country, by the execution of public works to develop her natural wealth. The system adopted in 1883 for any public works it seemed desirable should be undertaken was to create loans for the carrying out of the work, an imperial guarantee being given for the payment of a fixed rate of interest for a given number of years. As during the reign of the ex-Emperor these State obligations were never repudiated, and both capital and interest were always punctually paid on the works contracted for being satisfactorily completed, confidence was established in Brazilian loans in this country, and capitalists were always ready to invest in these securities. How far this may continue to be the case under the existing republic it is impossible at present to foresee, but if the credit of Brazil is not fully maintained in the future as it has been in the past, her progress will cease.

The sugar trade of Brazil is one of her most important industries. In no country in the world, unless it may be in the West India Islands, does the sugar-cane flourish to such an extent as in her fertile valleys, favoured alike by climate and soil, yet for centuries they have had but the rudest machinery at their native "engenhos," or factories for crushing the cane and making the sugar. Fully 40 per cent. of the syrup was thrown away for want of proper means of extracting the whole of the juice. When their enlightened Emperor saw what was done in other countries, he took immediate steps to put a stop to this annual waste of the national wealth of his country. To effect this he gave a concession to an English company to erect, and equip with the most approved modern machinery, large central sugar factories in various selected spots in his empire, and, radiating from each, to construct a sufficient number of miles of narrow-gauge railway into the surrounding cane-producing country to convey enough sugar-cane to keep each of such factories in full operation. To such a company he guaranteed for a period of twenty years 7 per cent. interest upon its capital expenditure from the time of the completion of the works. During that period any additional revenue over 7 per cent. would be taken by the State, and at the expiration of that time either a fresh period would commence on the same terms, or the works would be taken over by the State by payment of the capital.

It was upon works carried out by an English company and by English contractors under this system that I was employed in the province of Pernambuco, and it was the rapidity and ease with which we were able to push our little railways day by day, as I have described, through the tangled tropical forests that led me to consider how suitable such lines would be even if nothing but exploration was the object aimed at.

Perhaps it is not generally known, except by those who have travelled some distance into the interior of Brazil, how very little of this enormous country of three and a quarter millions of square miles is in any degree productive, and how much of it is entirely unexplored and unknown. Speaking generally, it may be said that from the Atlantic coast there is a strip of country about 100 miles in width in which sugar-cane is more or less extensively cultivated. Then, for a distance of another 100 miles or so, cotton is the staple production; then we have coffee, a large trade, two-thirds of the consumption of the world being, it is said, grown in Brazil. Within that area again we get hides, but the whole of the land producing these things extends only four or five hundred miles from the coast. Beside these productions there are tobacco, tapioca, diamonds, gold, and precious stones; but all are derived from within the limits of the area named.

Now, from west to east, at or near the Equator, Brazil measures 2630 miles, of which only some 500 miles are cultivated, or even known; and the question naturally arises, Of what does the centre of this enormous country consist? To this question up to the present time there has been no reply given. It is true that explorations of the Amazon and some of its tributaries have been made, but the high table-lands known to exist in the "Sertão," or Central Brazil, remain a "terra incognita." Such investigations as have been made of the Amazon show us outlying fragments, in the shape of isolated hills and mountains, near this great river, leading to a vast central table-land, estimated at from 2000 to 5000 feet high; but we know no more of the "Sertão" than this:—It is said to be inhabited by Indian tribes living in a state of barbarism, who have never, except some few who have made their way to the coast or the river, seen the face of a white man. What, therefore, may be the hidden treasures of Nature must remain mere matter of conjecture till revealed to us as the result of painstaking research.

Quite recently Colonel Labre has made some investigations in the central regions of South America, to which the President of the Royal Geographical Society made reference at their annual meeting this year, but this is, I believe, the only attempt ever made by a European to visit this vast territory in the interests of science.

My companion while at work in Brazil (to whom this little book is dedicated) often discussed this question, and we had a plan in contemplation, as soon as we had completed our labours, to endeavour to throw some little light on the subject by using our active and hardy little native horses for the purpose of seeing how far we could make our way into these unexplored regions. He is the only man I have ever intimately known with whom I would undertake what would have been so difficult and dangerous an expedition; but I believe that his energy, pluck, and perseverance, had we made the attempt, would have sufficed to pull us both through successfully, while his quick powers of observation would have been invaluable in making such an expedition. However, shortly before the completion of our works in 1884, he had an illness of so serious a nature that he had to be taken home almost in a dying state, owing to the height of the fever from which he was suffering; and so such plans as we had were never carried out. He has since, I am pleased to add, completely recovered, and been again engaged in railway construction in Venezuela.

We had often talked about the long ride we had proposed; of the rivers that must be crossed, either by swimming or fording; of the impenetrable jungle through which a path must be trodden, and of the unknown dangers of hostile tribes of Indians; also the snakes and reptiles that would beset us, as well as the difficulty of obtaining food as we left civilisation behind us. It is such difficulties and dangers as these, which must attend all exploring expeditions, that made the system of attempting them by means of such railways as we were then engaged in laying down seem reasonable and practical.

Progress is perhaps, as I have said, limited to from 6 to 10 miles in a week, and capital to the extent of £1000 a mile must be found; but, on the other hand, the rivers have permanent bridges thrown over them ; the road made through the jungle is a permanent road for future travellers. Stores and provisions of all kinds are brought to the front as the little railway advances, and the dangers arising from the attack of savage tribes, animals, and reptiles are certainly diminished. In times of sickness or of danger, the means of retreat to civilisation are also always at hand. Brazil, too, is a country where light rather than heavy railways are the most suited. No doubt costly railways would bring her prosperity, but it is not so certain that she would bring prosperity to expensively built railways. There is the "Dom Pedro Segundo Railway," 365 miles in length, and with no branch lines to feed it. For such a line without feeders it is impossible that sufficient traffic can exist to pay even working expenses, to say nothing of interest on the enormous cost of construction. It must be remembered that the produce of Brazil, as of all tropical countries, where cereals cannot grow, is very light in proportion to the acreage under cultivation ; and such countries, therefore, require only light and inexpensive railways to carry it.

We found that, to provide the 350 tons per day for each of the sugar factories, a very large area of plantations had to be connected, but, when so connected, the 2 ft. 4 in. gauge railway was fully equal to the work of conveying it. If we take coffee, we find the yield of a good crop only 500 lb. in weight to the acre, or in 1000 square miles the weight of coffee would be only 178,571 tons. In the same extent of land under wheat, the weight to be conveyed would be ten times as great. One-tenth of the carrying capacity of the railways, then, would suffice—a sufficient proof that tropical lines should be economically constructed and lightly equipped. Take other products, the same thing applies—cotton, spices, tobacco, gold, precious stones, &c., all valuable, but light for purposes of transport.

It is impossible for us to alter the conditions of Nature, but we can regulate our works to meet her requirements. We must take her as we find her, and, as all the resources of science can only make combinations of the materials at our disposal to render them of the utmost advantage to mankind, so trade and commerce can but convey in the cheapest possible manner raw materials from some part of the globe where, for want of demand, they are valueless, and serve only to cumber the ground which produces them, to some other part of the world where they can be used for the benefit of the human race. The more facilities that are given to effect this desirable object, and the more cheaply the transfer can be made, the more rapidly will civilisation spread.

CHAPTER V.

In all countries and in every corner of the earth the cry is for means of transport, and a ready response to that demand would be given by capitalists if it can be demonstrated that a certain and quick return will be forthcoming on the money so invested. With cheap railway communication, aided by a duly protected mercantile marine, the natural productions of foreign lands now inaccessible for want of land transport can be brought to the markets of the world, and, at the same time, new markets will be available for the ever-increasing manufactured goods of civilised nations in those countries from which supplies of the raw materials have been derived. All alike must participate in the advantage of this beneficial interchange of commodities, and not the least those who by judicious investment of capital enable it to be accomplished, and no such ready means exist as by the rapid extension on an economical basis of railways all over the world. I think no more instances need be taken, either in British possessions or in foreign lands, to show that ample scope exists for light narrow-gauge railways, in the first place, as a means for exploration, and, in the second place, for profitable commercial enterprise. I now venture to make a few practical suggestions as to the organisation, under this system, of exploration expeditions.

These might, I think, be State-aided or undertaken exclusively by a Government department for foreign exploration, or they might be left entirely to private enterprise under a chartered company, as in the case of the East African

Exploration Company; but, whichever plan were adopted, the essential requirements of a Government department or of a chartered national company would be the same.

The board of directors in the one case, or the heads of the department in the other, should consist of distinguished travellers, eminent civil engineers, men of science, especially having reference to geological and geographical research, as well as financiers who are well accustomed to conduct their operations on an extensive scale. The societies in this country that have done so much in establishing missionaries in heathen lands should also be represented.

The duties of a board of control so constituted would be with the sanction and approval of the Government of the day—

(1) To determine the circumstances of each particular exploration proposed in all its details, and to consider it in every possible light.

(2) Should the scheme be approved after the most searching inquiry, to obtain parliamentary powers for procuring the requisite capital, the amount required being based upon estimates prepared in accordance with the prospects of ultimate results in the future development of the country.

(3) To have full powers to make (subject to parliamentary sanction) direct treaties with colonial Governments or with foreign Powers to construct railways, harbour works, or public works of any other description in any part of the world; to acquire land for the purpose of the construction of such works on such terms as may be arranged, either by absolute purchase or by lease for a fixed period; to have full power and control over the works so constructed, and the power to employ them to the full extent for the benefit of the company, or to lease or sell them to any Government or corporate body subject to the approval of the British Govern-

ment and of the Government of the country in which such public works are situated.

(4) After due consideration of any particular project, and it having been decided to adopt it, and preliminary negotiations settled on the lines indicated, bonds or shares would be issued of sufficient value and on such terms as might be decided on to carry the work into effect.

(5) Investors taking up shares or bonds for any particular exploration would have an interest in the general business of the company only so far as that portion of it to which their shares related, but would be entitled to be represented by a certain number selected from their own body to act with the general council as directors in respect to that particular undertaking only in which they were interested, and their proportionate power of voting would be duly specified.

Sanction given to an exploration scheme by the general council, consisting of the most capable men in every branch of science, and having on its staff the most eminent explorers and engineers, as well as great financiers, would in itself form a sufficient guarantee to the public that any scheme so sanctioned, and having also the approval of our own Parliament and that of the colonial or foreign Government, as the case might be, was a scheme as to which no possible doubt could exist, and the bonds or shares of an exploration undertaking, so promoted, would be readily taken up, and become at once marketable.

The original capital of the parent exploration company should suffice for the cost of establishment, incorporation, offices, and clerks, directors' fees and salaries, or retaining fees to such professional men as might be engaged upon its staff, law costs, stationery, printing, &c.; also for defraying the expenses of explorers and engineers sent for pursuing investigations in foreign countries.

It should be provided with steel rails, fastenings, steel sleepers, and all requisite tools and plant, together with such portable appliances as are manufactured for construction of light railways, and sufficient of such appliances should be provided, together with engines and rolling stock, for the immediate laying down of some few hundred miles of narrow-gauge railway.

The staff of the company should include engineers well accustomed to the setting out and construction of light railways of this description, as previously described, in the best and most expeditious manner, on receipt of instructions from the Home Office as to the line of country and general direction to be followed.

All such plant in connection with these railways that can be conveniently exported should be held in readiness by the company for immediate despatch to any part of the world, as well as such medical and other stores that their officers abroad might require from time to time.

The services of some large firm of English contractors should also be at the disposal of the company in the event of its being considered to be desirable that the company should avail itself of such assistance to carry out the work.

Any of these facilities for rapid and economical construction would be placed at the disposal of any particular exploration company brought out under the auspices of, or promoted by, the parent company, and in such case the particular company would be debited in the books of the parent company with the actual cost of the assistance so rendered, and would, in addition, pay to the parent company a percentage, previously fixed, on all its future earnings.

The profits, then, of the original exploration company would be derived from—

(1) A percentage on the earnings of any company promoted by it.

(2) Revenue derived from any undertaking carried out by itself.

(3) The selling or leasing of any railways or other public works to colonial or foreign Governments, or to any corporate body approved by them.

This, then, is the roughest possible outline of the proposed scheme for the employment of light railways as a practical means for exploration. As an engineer, it is not within my province to formulate the somewhat complicated machinery necessary to effect in the best possible manner the objects I have in view. Draughting the Articles of Association of a corporate society of this magnitude must be left to abler hands than mine, and I should not have ventured on the subject of organisation at all except to make my meaning in some degree intelligible.

The idea may possibly be deemed as worthy of consideration, and I feel sure if the details were properly worked out (a task far beyond my powers), and future explorations by this system took a practical shape on an extensive scale, the result would be the rapid advance of Christianity, commerce, and civilisation in foreign lands, and the providing employment for the manufacturing industries and ever-increasing population of our own country.

CHAPTER VI.

Before concluding my subject I purpose to consider the construction of light railways for military and strategic purposes.

In modern warfare the use of them is not unknown, nor are the advantages of employing them entirely matter for experiment. The plan was adopted by our War Department in the first Egyptian campaign, when Fisher's armour-clad train was an important feature, and contributed in no small degree to our success. Some few miles were laid down on the bank of the Sweet Water Canal, and it was, I believe, by its means that Arabi was eventually taken prisoner. I think this is, however, the only instance of its use in actual warfare.

The undoubted success attending the plan as then proved would be an unanswerable argument in favour of adopting the same system in future, and our military authorities will consider that no army of occupation is complete or adequately furnished without some miles of this equipment. Our War Department should, then, have always in readiness for shipment, in the event of emergency, sufficient of the requisite material of the most approved construction, and also all necessary tools, including complete contractor's plant, for preparing rapidly the formation and for laying down the permanent way.

I would suggest, further than this, that there should be a trained corps of engineers and workmen entirely under military discipline, who should be thoroughly accustomed to, and expert, not only in the laying down of the permanent way, but also in the construction and the setting out of railways—in point of fact, as efficient in all such duties as are now undertaken by civil engineers and carried out under their supervision by a competent contractor's staff, whose navvies are engaged all their lives in works of this nature.

It will of course suggest itself that in the Royal Engineers and Sappers and Miners the War Office have already at their disposal an excellent body of men capable of constructing strategic railways for military purposes in the best manner, and, no doubt, the special training of military engineers has enabled the Government to make use of their valuable services in times of peace in engineering and surveying work, outside the sphere of their special duties, with advantage.

For example, in that great work of the Ordnance Survey of England and Wales, which will for ever remain a lasting record of the efficiency of that distinguished corps, their services have been for some years most usefully employed in work which formerly was done exclusively by civilians. Still, although this is no doubt the case, I do not think it would be found that the training either of officers or men is such as to enable them to undertake the work of railway construction in the most efficient and most economical manner.

Then, again, although, as we have seen, in times of peace their services have been utilised in work which seems more properly to belong to civil engineers, in time of war this could not be the case, as then they would have sufficient duties to perform in their more legitimate sphere of action.

I think, then, it may be said that the construction of military railways for strategic purposes ought not to be added to the duties which, in time of war, the corps of Royal Engineers would be called on to fulfil. On the other hand, to employ a disorganised body of civilians, however expert they may be in this special work, might prove an unwise step. The General commanding an army of occupation would possibly be hampered in his operations by a by no means inconsiderable body of irregular camp followers, who would not be subject to direct military authority and discipline, and it is of course of the most vital importance that this should not be allowed to be the case.

In order to meet this difficulty the following plan has suggested itself:—That a special corps might be formed which might be called the Military Railway Engineers Corps; that they should form a part of our Army Reserve, and be enrolled on similar lines to our Militia. They would be drawn, as regards their officers, from Civil Engineers and others who have had most thorough practical knowledge and experience in the laying out and construction of railways; and as regards non-commissioned officers and men, also from those who have worked as foremen and navvies for railway contractors. Such a force so constituted would be called up, like the Militia, from year to year for an annual training, and, on being disbanded, would revert to their ordinary occupations, but would at any time be liable to be called upon, in case of emergency, for foreign or other service, being at such time under complete military control. They would of course carry arms and be trained in their use, and, although non-combatants, they would be capable of employing them for their own defence.

The annual training of such a corps so organised would, in addition to the ordinary drill of a soldier, have reference to their special work. Here, as regards the selection of a camp where the actual work of constructing a railway could be undertaken, some difficulty at first sight presents itself, but I think this could be overcome successfully.

There are in this country, more especially in the Lake districts, in Wales, and in parts of Scotland many landed estates in which the owners of the soil as well as the tenants require increased means of communication, by road at any rate, if not by rail, and in such mountainous countries as I have in view the land is of little or no value for cultivation. In such cases it would not, I think, be difficult for the Government to obtain the sanction of the landowner to lay out and to construct the earthwork necessary for the formation of a railway of a width of about 12 or 15 feet from place to place, and to build the bridges, culverts, and other requisite works in connection therewith. Upon the formation so made the permanent way of the light railway suitable for military purposes would be laid, and this, as well as engines and rolling stock, would be supplied for a section of say 10 miles in length from the Government stores. The Railway Corps would, during the training, be practised in the earthworks, the laying rails, ballasting, and the running engines and working of the line, and, at the end of the training, the rolling stock, rails, sleepers, and all portable plant would be again returned to store, leaving the formation so prepared to serve as a road for the convenience of the neighbourhood. In the following year, in a similar way, the same road might be continued, or others made in other parts of the country.

Thus a Military Railway Corps would soon become very expert and proficient in all the duties of railway construction, and especially so in the rapid laying, taking up, relaying, and transporting the permanent way and the engines, trucks, and other material from place to place, so that when called upon to perform these duties in times of war their services would be invaluable.

I do not profess to any knowledge of purely military matters, but I assume that an army of occupation must by some means make good all such territory as is acquired by force of arms, and guard against surprise and recapture. The commander of such an army would also desire to establish rapid and easy communication with the coast, and to have the means of supplying such fortifications as he might capture or construct with arms and ammunition for its defence, as well as stores and provisions for the support of the garrison, who may in a hostile country be cut off from supplies if a line of communication be not made and kept open with the sea-board and the fleet.

By means of suitable narrow-gauge railways, properly constructed and rapidly laid by a well-trained and thoroughly disciplined regiment of railway engineers, all this and much more could be effected.

Reinforcements as soon as they were landed would be conveyed quickly to the front, while the sick and wounded would be sent down to the coast, to be embarked for home or to remain in hospital on shore under the protection of the ships. By the same means the troops would be quickly supplied with all requisite stores, arms and ammunition, and light field-guns at any rate, if not the heavier artillery, in specially constructed trucks could be conveyed at a speed of 15 to 20 miles an hour over the railway—thus saving much of the tedious and laborious work, both to men and horses, of dragging guns and ammunition waggons over rough and broken ground. Waggons for artillery would be made like ordinary gun-carriages, mounted on strong wheels and axles, to run upon the rails. The gun would be mounted upon trunnions in the ordinary way, the under portion of the carriage being made to swivel upon the bogie principle, and with a brake as well as a locking apparatus to grip the rail, so that a gun may be brought into action, trained, and fired upon the railway itself. A few such guns would serve to protect the railway from being cut or destroyed.

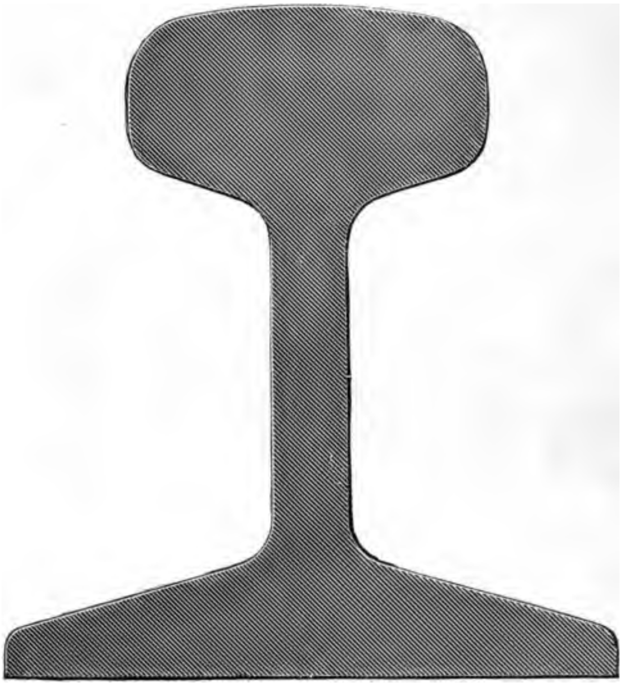
For the transport of cavalry, if required, proper horse-boxes should be provided. Also ambulance carriages of suitable construction for the wounded.

I need not here go into further detail as to the organisation or equipment of such a Railway Engineers Corps as I have attempted to describe. Their uniform would, of course, be designed in accordance with the duties they had to perform, and would be strong and suitable for rough work.

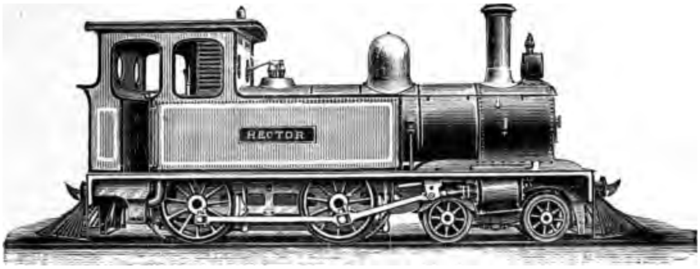
In considering the cost of military railways, we must depart from the estimate previously given for narrow-gauge railways for exploration purposes.

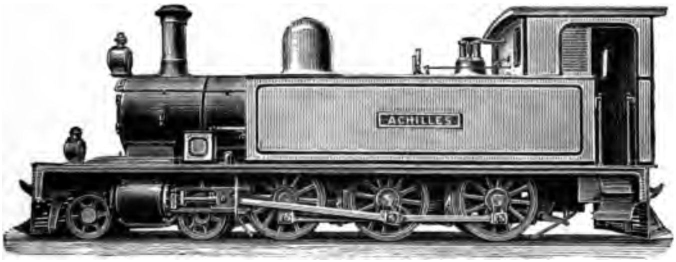
In the first place, the object to be gained is different. Exploration railways, as we have seen, are, in the first instance, for the purpose of developing in the quickest and most economical manner countries which, for want of communication, contribute nothing to the wealth of nations, and, secondly, for creating trade and commerce. Economy in construction, therefore, in order to insure a return upon capital invested is the first consideration, the whole matter being conducted upon a commercial basis. In constructing railways, however, for military and strategic purposes the conditions are altered and the requirements are different. Efficiency should be in this case of paramount importance. It is no question of commercial success, and the return for the expenditure would consist in the saving effected in lives and money by bringing bloody and costly wars to a more speedy termination.

Railways for these purposes also would have heavier freights to transport. Carriages and waggons should be protected by steel armour plating, and guns and gun-carriages mounted on wheels as has been described would be of considerable weight. The engines would therefore be, of course, proportionately heavier, as would be also the permanent way. As regards the question of gauge, I should say the metre, or 3 feet 6 inches, would answer all requirements the best. The rails should be of steel, and weigh not less than 40 lb. to the yard; the sleepers also of rolled steel, and not less than 1920 should be used in a

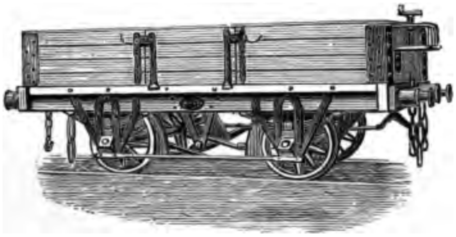


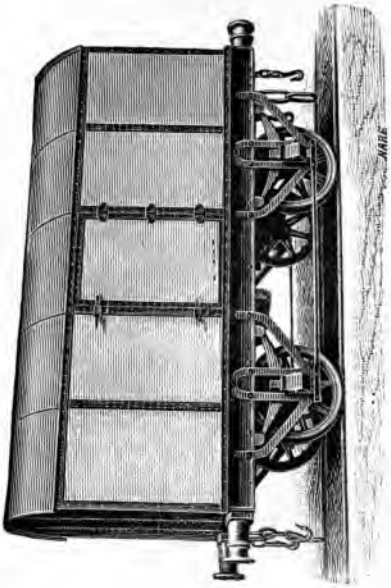
40 LB. PER YARD.

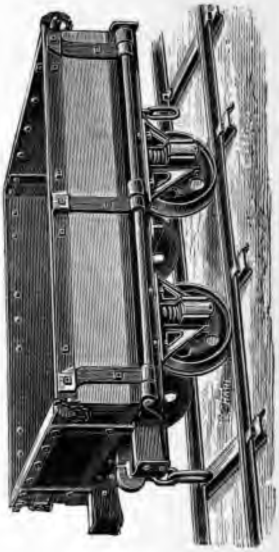


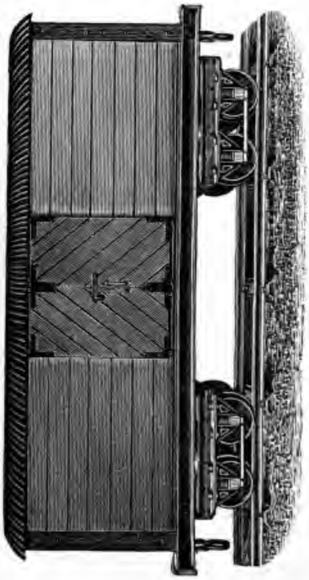


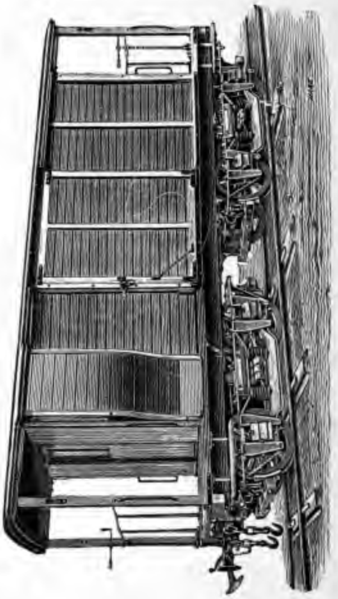
LOCOMOTIVES.

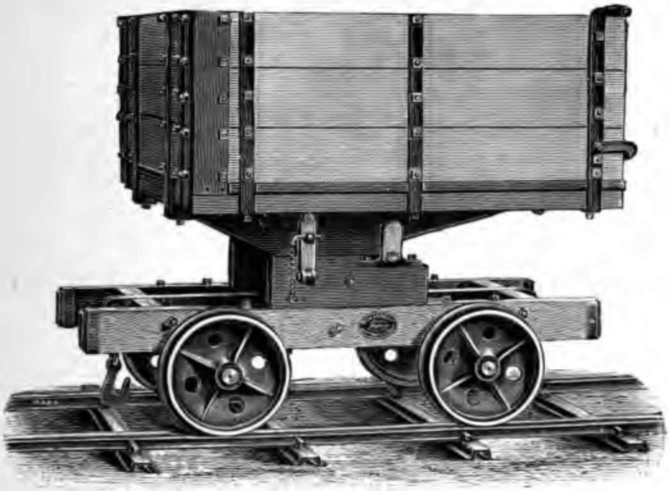


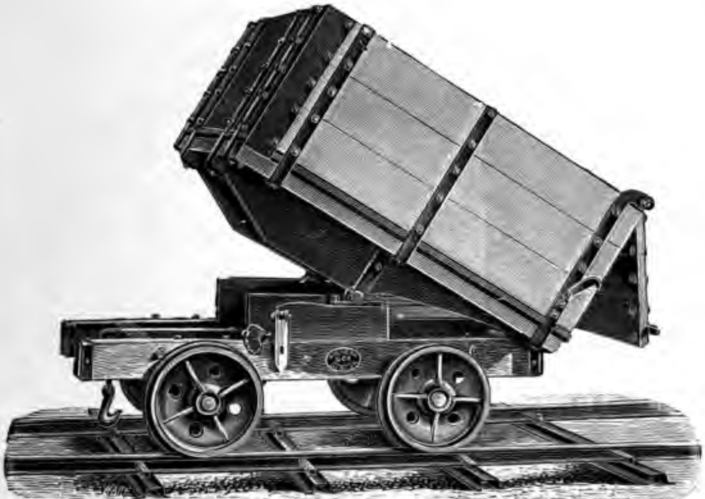


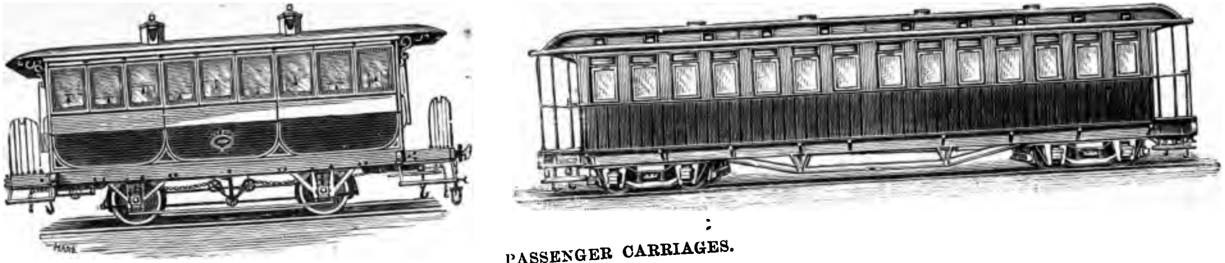




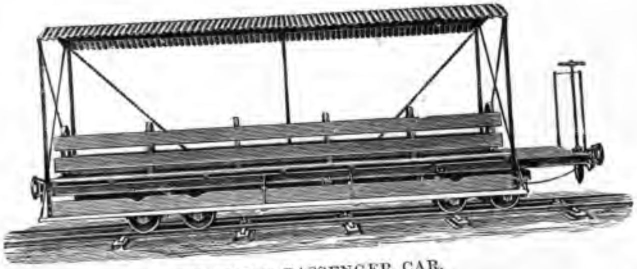




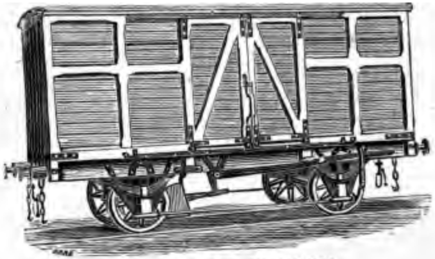




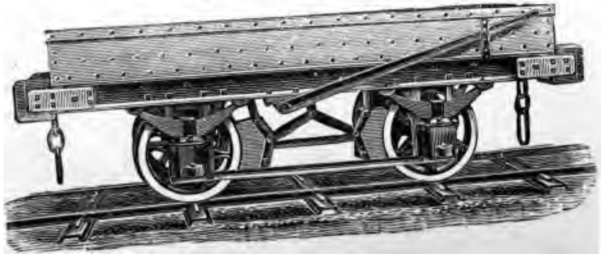
PASSENGER CARRIAGES.



OPEN BOGIE PASSENGER CAR.



COVERED GOODS WAGGON.



mile. The flange of the rail is attached to the sleeper by holding-down steel angle clips and bolts, and the ends of the rails are secured by fish-plates. The cost per mile of a single line of permanent way of the above description of 3 ft. 6 in. gauge I should estimate thus:—

	£	s.	d.
Rails (40 lb. per yard), 63 tons at £6	£378	0	0
Fish-plates, 2¼ tons at £7	15	15	0
Fish-bolts, ½ ton at £15	7	10	0
1920 steel sleepers and fastenings at 3*s*. 9*d*.	360	0	0
Cost per mile	£761	5	0

The steel sleepers would weigh about 60 tons, and the total weight of 1 mile of permanent way as above would be 126 tons. Assuming that the Government provided 10 miles of railway in readiness at all times for shipment, there would be required also sufficient appliances, in addition to the engines and rolling stock, for this length of line. I should estimate the entire portable equipment for 10 miles, exclusive of rolling stock, as follows:—

10 miles of permanent way	£7610
½ mile of sidings	380
20 sets of points and crossings	50
2 engine turn-tables	90
4 carriage „	60
Pumps and hydrants	150
Water-tanks	80
Sheer legs and crabs	100
Cranes and hoists	60
Carts, barrows, and tools	80
Platelayers' tools	30
Fitters' tools	60
1 portable workshop	150
Lathe drill and forge	100
Hydraulic and other jacks	50
Chains, ropes, and tackle	50
Rolled iron girders	400
Miscellaneous plant	500
Portable equipment for 10 miles	£10,000

We come next to the rolling stock, and shall have first to consider the engines.

Three first-class locomotives would, I think, suffice for the 10 miles of railway under consideration. An excellent type was supplied by Messrs. Dick, Kerr, & Co. to the Delagoa Bay and East African Railway Company for running heavy trains over sharp curves and severe gradients. Illustrations of these, with particulars and prices, I extract by permission from their catalogue.

Diameter of Cylinders.	Length of Stroke.	Water Capacity.	Fuel Space.	Will haul on Level.	Will haul on 1 in 50.	Weight.	Price Complete.
inches.	inches.	gallons.	inches.	tons.	tons.	tons.	£
"Hector"—							
10	16	400	30	226	50	20	1390
12	18	600	36	320	76	22	1585
13	20	600	36	420	103	25	1645
14	22	800	40	500	125	28	1715
"Achilles"—							
12	18	600	40	320	76	26	1635
13	20	700	40	420	103	30	1785
14	22	800	46	500	125	33	1895

I should select from this list for the three engines as the most suitable for the purpose I have in view the 10- and 12-inch locomotives of the "Hector" class (the two first on the list) and the 12-inch cylinder engine "Achilles." These three locomotives, fitted complete with steam brakes and cow-catchers, would cost £5110, and the dead weight 68 tons for the three engines.

As regards particulars and cost of other rolling stock which would suffice for the 10 miles of railway of metre or 3 ft. 6 in. gauge, I give the following list, which is exclusive of any carriages of special design for mounting field-guns:—

Ordinary Rolling Stock.

20 contractor's earth waggons	£320
10 „ end-tip „	200
5 „ side-tip „	110
10 platform waggons	110
5 high side goods waggons	260
5 low „ „	240
4 covered goods waggons	280
20 passenger cars, to hold 20 passengers each	900
20 open goods waggons	260
4 brake vans	320
103	£3000

I should estimate the weight of these 103 carriages at about 280 tons. In addition to contractor's and ordinary rolling stock, there should be carriages of special design for purely military purposes. These would consist of gun-carriages, powder or ammunition vans, forage waggons, horse-boxes, and ambulance cars. They should be well and strongly built, and protected by steel armour plate, and I should estimate the cost as follows:—

Military Rolling Stock.

10 carriages with mountings for field-guns (exclusive of guns, but fitted with the apparatus for training, elevating, and depressing, and with iron hoods or mantels, for protection of gunners, mounted on strong bogie wheels, and with brake and gear to grip the rails)	£1500
10 covered powder or ammunition vans, armour-plated, all of iron or steel	800
10 open forage waggons, skeleton iron sides, and with waterproof sheets	300
10 horse-boxes fitted and protected by armour plate, each for two horses	800
2 ambulance cars (as illustrated) protected by armour-plate	300
10 carriages for conveying heavy guns, made like timber waggons (as illustrated), on strong bogie frames, to work on swivel	800
52	£4500

The portable equipment, then, for the Railway Engineer Corps would consist of—

10 miles of permanent way of 3 ft. 6 in. gauge, with plant, tools, &c.	£10,000
3 engines	5,110
103 carriages, ordinary rolling stock	3,000
42 „ military „	4,500
	£22,610

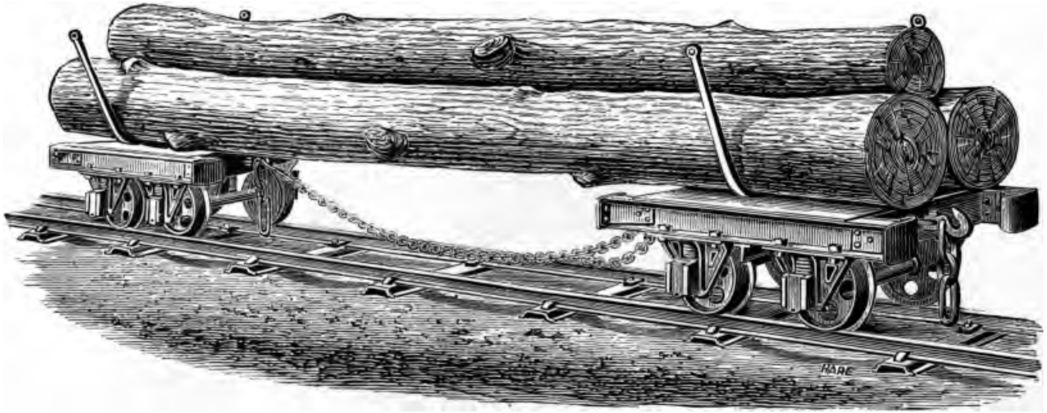
I calculate the total weight thus:—

	Tons.
Permanent way, plant, &c.	1436
Engines	68
Ordinary rolling stock	280
Military „	350
	2134

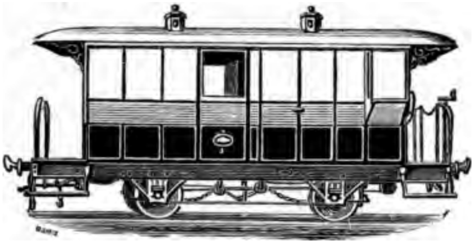
I do not take into account the cost of construction of the railway, as that would be included in the cost of the maintenance of this auxiliary force called up in time of war for the special duties in connection with the laying down of the railways.

The cost per head of officers and men would be much the same as in any other branch of the service. In addition to the special equipment, which we have estimated at £23,000, there would, of course, be the clothing, arms, and stores supplied to the ordinary soldier. As we have based our calculations upon a length of 10 miles of railway, we will estimate the strength of the corps as sufficient to construct this length of line in a reasonable time.

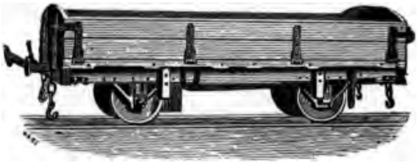
Sixty thousand cubic yards of earthwork would be a fair average for 10 miles of formation, 11 feet wide, with slopes 1½ to 1. 300 men, getting 6 cubic yards a day each, would

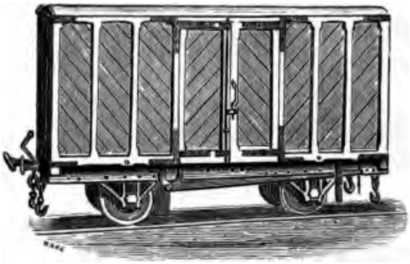


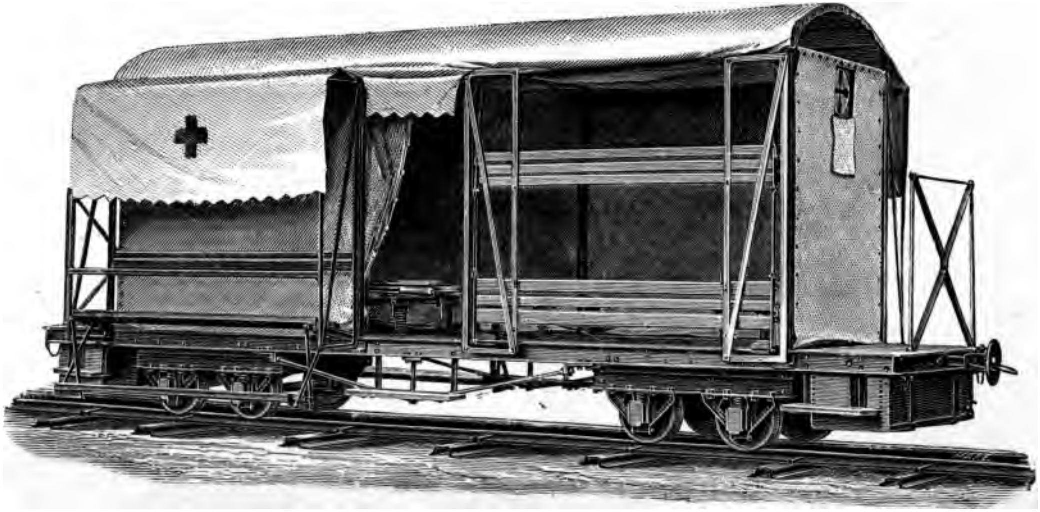
TIMBER WAGGONS, TO BE USED FOR TRANSPORT OF HEAVY GUNS.



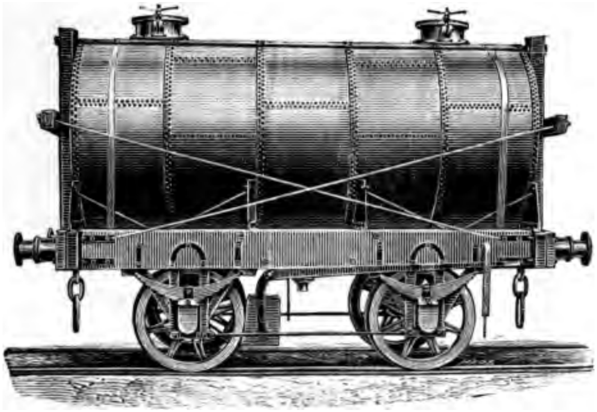
GUARD'S VAN.



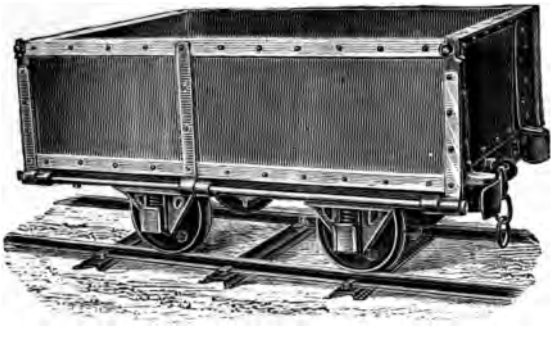


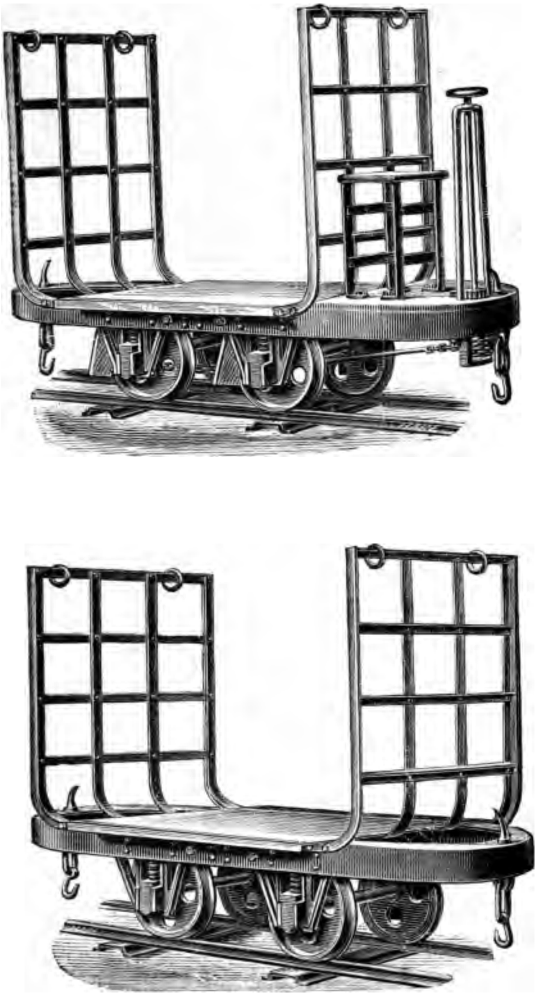


AMBULANCE CAR.



WATER TANK.





FORAGE WAGGONS.

accomplish this in thirty-three or thirty-four days. In addition to these 300 men, there would be platelayers, engine-drivers and stokers, cleaners, fitters, and mechanics, say another 100. With officers and non-commissioned officers, I should put the full strength of an efficient corps at from 450 to 480 men, capable of laying down the 10 miles of railway in about a month. The cost must also be considered of sending these 480 men where their services are required, and also the freight of the 2134 tons of equipment.

Taking it all together, the cost is no doubt considerable, though as nothing if compared to the maintenance of a battery of artillery of similar strength. The latter are at all times on a war footing, while, except in time of need, the former are called up once a year only for training, and then are engaged on works for the benefit of the general community; also, the equipment of a battery of artillery, according to modern practice, would, I should think, cost as much as, or more than, the requirements for an Engineer Railway Corps as here sketched out. At any rate, I have no doubt but that such a corps would prove a most powerful auxiliary force, and, if while under perfect discipline as soldiers they are at the same time thoroughly efficient as railway engineers, the employment of them would lead to the quicker termination of any wars on which we should be unhappily engaged, and in this way be the means of saving both the resources of their country and the lives of their fellow-countrymen.

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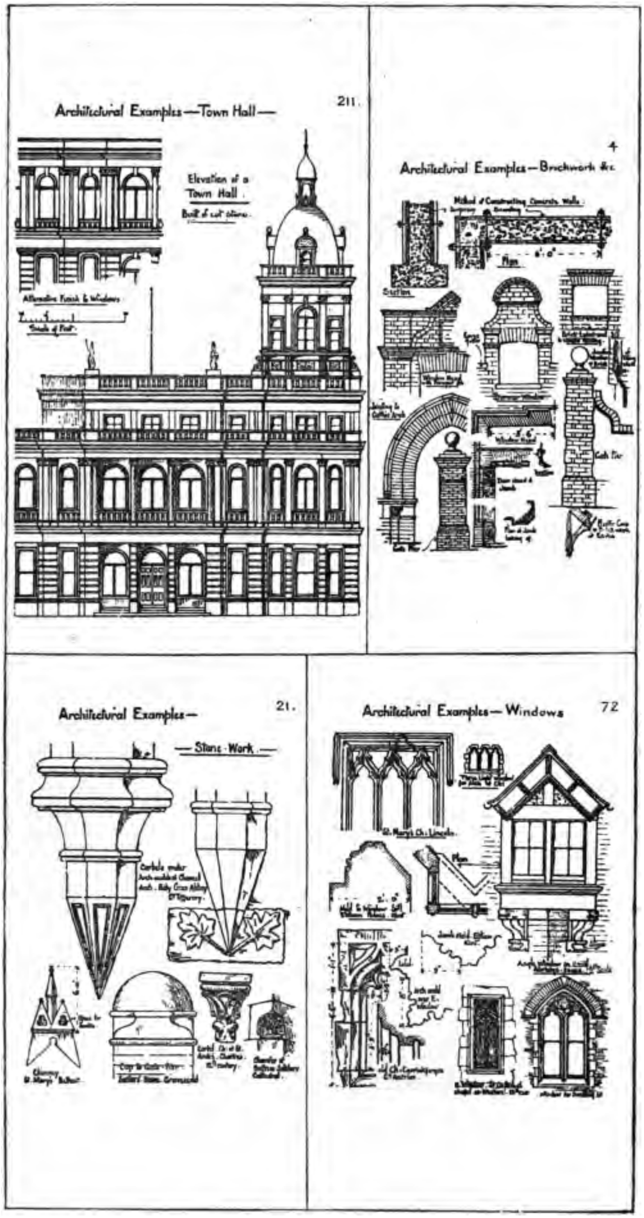

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